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THE DECEMBER SCIENTIFIC MONTHLY

EDITED BY J. MCKEEN CATTELL

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THE SCIENTIFIC MONTHLY

DECEMBER, 1933

TREE GROWTH AND CLIMATIC CYCLES

By Professor A. E. DOUGLASS

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THIS paper discusses certain variations in the width of the annual rings of trees that suggest, through climate, a relationship to the sunspot cycle. Since tree rings form the vehicle in which the variations are found, some reference to them is necessary by way of introduction.

The total number of rings carefully examined as to growth date is well over half a million. They are grouped in some 5,000 specimens, mostly different trees. About 250,000 rings have been measured with care after accurate dating in all cases, except, of course, the geological rings. The collection and measurement of some fifty giant sequoia sequences, together with general climatic studies, received the generous assistance of the Carnegie Institution. The collection of specimens and dating of prehistoric ruins in Arizona and New Mexico back as far as 919 A. D. was most helpfully financed by the National Geographic Society. The Research Corporation of New York, the American Museum of Natural History, the Museum of Northern Arizona and a number of friends have each made important and valued contributions. The University of Arizona has given a substantial portion of my time.

The discovery in 1911 that dates of individual growth rings may be recognized accurately in tree after tree over wide areas has resulted in the building of a 1,200-year tree ring chronology in Arizona and New Mexico, and has placed the interpretation of tree growth on a climatic basis. The development in 1913 of a method of cycle analysis of greatly increased efficiency gave a completely new approach to the type of cycle here involved, that is, the apparently discontinuous cycle. This method recognized the value of the "residual" method of plotting cycles and the rapid and flexible graphic correlations possible in the automatic cyclogram. The cycles here quoted as found in tree ring records have been picked out in the original data from a considerable range of cycle values and are not the result of tests of selected values, for a special feature of the cyclogram is the wide range of cycles visible at once. Each cycle is first recognized in its extended form, of which integrations, such as shown in this paper (Fig. 11), may be made if desired.

Any relationship between cycles in tree rings and cycles in the sun must almost certainly take place through the medium of the weather, which influences tree growth and in turn is energized by solar radiation. Hence the relationship between tree growth and weather is of primary importance.

The theoretical basis for the climatic interpretation of tree growth may be expressed as follows: If many widely separated trees in a uniform area show the same variations in the same years con-

tinuously (that is, for hundreds of years), then these variations are climatic in nature, for climate is the common continuous factor in the life of the forest trees.

A second principle of interpretation brings us a little closer to the dominant meteorological element in the trees, namely, that a forest limit may isolate the climatic factor involved. Thus, for example, the lower pine forest border in Arizona, which separates the successful forest from the desert below, is a matter of altitude and therefore water supply, which in that region depends on altitude. The trees near this forest limit therefore give prominence to a rainfall record, though other factors are there. This is shown in Fig. 9 in which agreement is shown between tree growth and rainfall at Prescott, near the lower forest border of the Arizona pines. The lower pair include some conservation and have to each other a correlation coefficient of 72 per cent.

Fig. 10 gives us a similar comparison for Southern California areas. In the upper set, three curves are compared in their original values; in the lower set the smoothed values are shown. The first curve gives Lynch's Rainfall Indices, 1770 to 1930, for the Los Angeles area, including San Diego records after 1850. The second curve is from sixteen pines in the San Bernardino Mountains at about 6,000 feet elevation, in the large Santa Ana Valley northeast of Redlands and lying just east of the rainfall area considered. Here the resemblance to rainfall is quite evident, especially in the minima. The correlation coefficient between these two curves from 1770 to 1930 is 45 per cent. and 5 per cent. probable error, a correlation that is certainly not accidental.

The third curve ties in the sequoias, even though the correspondence is not so marked. It represents the average of four large trees that grew near General Grant National Park on steep upland slopes, thus avoiding the water conservation of the swampy basins. The distance between rainfall area and tree area is 200 miles. The correlation coefficient here is 28 per cent. and 5 per cent. probable error for values since 1770. This correlation was examined by Dr. Dinsmore Alter and considered very probably real. This is less than the former, as expected from the greater distance. These correlations were computed by Dr. W. S. Glock. This comparison just obtained confirms the estimate previously made that water supply, while less vital than in the Arizona pines, is still an important factor in the sequoias. The accuracy of sequoia dating was carefully checked again in 1931.

Thus the tree growth cycles shown later may be safely taken as having a strong climatic significance, with rainfall as the probable major element.

I. The Hellmann Cycle

Many tree groups show, since 1850, an 11-year cycle with two crests. This cycle in actual length varies from 11.2 to 11.8 years, with perhaps the commonest value at 11.4. This compares favorably with 11.35 years, which is the average sunspot cycle length since the maximum of 1837. The two crests usually are somewhat unequal in height and in spacing and in stability. In most cases one crest comes near sunspot maximum and the other near sunspot minimum. The one at maximum is much more stable than the one at minimum.

A cycle that fits this description was found by Hellmann in 1906 in North German rainfall. It is shown in Fig. 11a. Though Hellmann had little confidence in this relation to the solar cycle it seems to be sufficiently frequent in trees to justify using his name. In the figures the sunspot minimum is inverted and turned into a second maximum and carefully marked in every case. By this slight modification the eye is better able

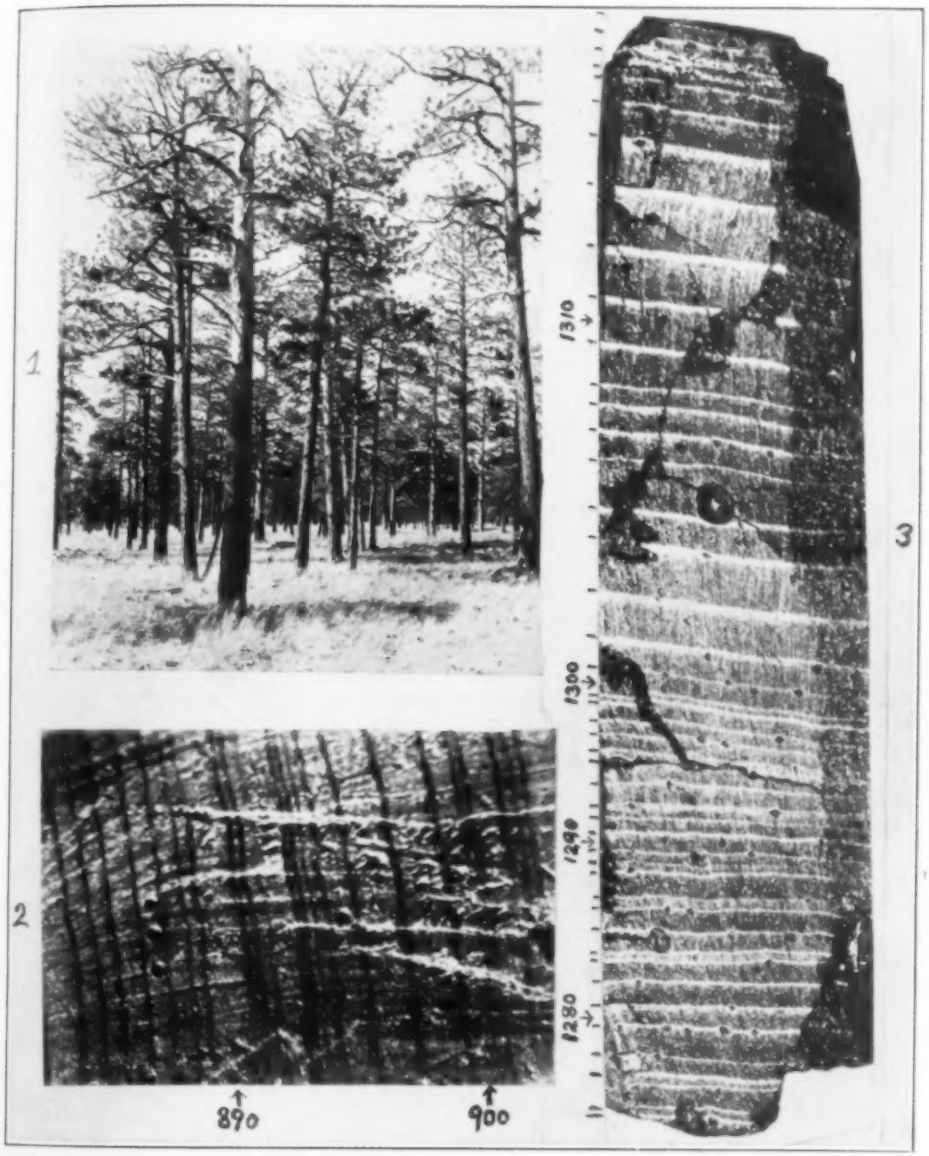

PLATE 1: 1. NORTHERN ARIZONA PINE FOREST; PHOTOGRAPH BY U. S. FOREST SERVICE. 2. FINGER PRINT OR IDIOGRAM A. D. 890–9, A CONFIGURATION OF RINGS EXTENSIVELY USED IN CROSS-DATING. 3. THE GREAT DROUGHT, 1276 TO 1299, AS SHOWN IN CHARCOAL FROM SHOWLOW, ARIZONA; BEST ARIZONA RECORD OF DROUGHT YET FOUND; NOTE THE FAVORABLE CONDITIONS FOLLOWING THE DROUGHT.

to catch uniformity or variation in the Hellmann cycle.

The existence of this cycle and the others mentioned below is based on the cyclogram patterns in Fig. 8, in which the letters correspond to the letters in Fig. 11. The cyclogram has two important characters. It is first a plot of the differences between an exactly repeating period and the observed maxima, and so cycles become separated, since they appear as lines pointing in different directions, and second, it is not merely a plot of selected maxima, it is an automatic plot of the entire data, usually smoothed by Hann's formula. Hence it is not a plot of points here and there, it is a multiple reproduction of the data in such form that correlations become at once apparent as a new feature. Such are the horizontal alignments shown in the various patterns of Fig. 8, which correspond to a cycle length of 11.4 years. The patterns carry two examples of this alignment, one above the other, as may be seen. A two-crested sunspot cycle, such as the Hellmann cycle, produces double that number of horizontal lines. For example, the last pattern, l, is taken directly from the sunspot cycle itself with the minima inverted. Such inversion turns it into the Hellmann form. Thus the existence of a Hellmann cycle in any pattern may be judged by its similarity to l.

In Fig. 8a Hellmann's curve of German rainfall is extended to 1920 by the Berlin rainfall record.

In 1912–13 eighty North European trees were sampled. Several hundred dates of maximum growth between 1850 and 1907 are collected in Fig. 11b (and 8b), which gives the result of this single qualitative test in a symmetrical Hellmann cycle. The only difference from Hellmann's curve is in the greater relative height of the crest at maximum. This curve has been reproduced in extended form in Vol. I, "Climatic Cycles and Tree Growth," page 78. The correlation coefficient between full curve and the sunspot numbers is $+.57 \pm .07$.

Fig. 11c represents a group of twelve trees from Dalarne, Sweden. The mean curve of the twelve, between 1830 and 1907, based on 900 measures, places the larger maximum directly over the sunspot maximum. The minimum crest nearly disappears. The extended curve was reproduced in Vol. I, just mentioned, page 75. Its correlation coefficient with the sunspot numbers is $+.62 \pm .06$.

In an interesting group of thirteen trees from Eberswalde, Germany, 1,100 measures, between 1825 and 1907, the minimum crest has practically gone, except in a very few cases, leaving a massive crest at sunspot maximum. This is shown in Fig. 11d. The extended curve has been reproduced in the same volume, page 75. Its correlation coefficient with the sunspot numbers is $+.51 \pm .07$.

Six groups, 57 trees, of the nine North Europe groups collected in 1912 show in their cycle average between 1830 and 1910 a good replica of the mean sunspot cycle, as can be seen in Fig. 11e. This includes about 4,500 measures. The minimum crest occurs rarely and disappears in the average. The extended curve has been reproduced in the same volume, page 77. Its correlation coefficient with the sunspot numbers is $+.56 \pm .05$.

Now we consider tree groups in the United States. A Vermont curve from eleven trees and some 600 measures, 1852 to 1911, shows a strong 11-year cycle with one crest much more prominent than the other, and two or three years phase displacement. The range of variation is about 28 per cent. of the mean value. The correlation coefficient is $+.53 \pm .06$, after allowing for lag of -3 years. Seventeen Douglas firs on the Oregon coast, 900 rings measured, 1854 to 1910, reach a single crested cycle with a range of about 10 per cent. There is also a slight lag. The corre-

PLATE 2: 4. GENERAL GRANT TREE, CALIFORNIA; PHOTOGRAPH BY THE AUTHOR. 5. COMPLACENT SEQUOIA RINGS IN WELL-WATERED BASINS. D–8, REDWOOD BASIN. 6. SENSITIVE SEQUOIA RINGS ON STEEP UPLAND SLOPES. D–5 IN SAME REGION. 7. EBERSWALDE SECTION WITH SUNSPOT MAXIMA MARKED; THE LAST IS 1905; 1894 IS DISTORTED BY A PEST EFFECT (PUBLISHED IN "CLIMATIC CYCLES AND TREE GROWTH," CARNEGIE INSTITUTION, 1919, PLATE 8A). 8. CYCLOGRAMS OF ORIGINAL DATA SHOWING HELLMANN OR SUNSPOT CYCLE CONTINUING THROUGH THE DATA; A AND F ARE RAINFALL RECORDS; OTHERS ARE TREE RECORDS; L IS SUNSPOT CYCLE WITH INVERTED MINIMA FOR COMPARISON; SEE TEXT, AND NOTE AT END.

lation coefficient is $+.45 \pm .07$, after allowing for a lag of -2 years.

The largest American groups come from California and Arizona. These are perhaps best introduced by curves from the Southern California rainfall, using "Lynch's Rainfall Indices," as shown in Fig. 11f, extending back to 1770, a very important and useful compilation verified by the San Bernardino Mountain tree record. These indices since 1850, of course, became actual rainfall records. Smoothed curves of this rainfall have an obvious resemblance to the Hellmann cycle. Cyclogram analysis, 1855–1901, showed interference by a double-crested 14-year cycle and a short variation, apparently a little more or less than two years, which causes an apparent scattering of yearly values. Without these the Hellmann cycle becomes an excellent cycle with more than 30 per cent. range. A study is now being made of this two-year cycle to see if it can be distinguished from accident.

Fig. 11g shows the Hellmann cycle in the sequoias. This comes from the tabulated means of eleven trees, about 600 measures, published by the Carnegie Institution in 1919. The data originally covering 1810 to 1914 have been extended to 1930 by collections in the Sequoia National Park. The trees are complacent and the range is small, namely, about 8 per cent., but the maxima are clean cut and the crests are very stable as there is little interference from longer cycles. A cyclogram study of this sequoia record extended back to 1804 is shown enlarged in Fig. 8m.

Fig. 11h shows the Hellmann cycle in the southernmost sequoia grove, south of Sequoia National Park and near Springville, where three 3,000-year trees have been found. This curve is made from 500 measures covering 1805 to 1890. The topographic conditions are good but not the very best obtainable for a climatic record, since the area is rather flat and the ground sometimes moist. After removing by mathematical methods a 19-year cycle, the Hellmann cycle is evident with a range of 15 per cent.

Fig. 11i shows the Hellmann cycle in the San Bernardino pines, derived from 800 ring values, about 1850 to 1900; Fig. 8i uses the larger interval, 1825 to 1925. These trees grew at about 6,000 feet elevation in Santa Ana Valley, northeast of Redlands. Collection and measurement of this group was made with the generous help of Mr. J. J. Prendergast, president of Bear Valley Mutual Water Co. Here a 14-year cycle was strong. On subtracting it from the data the Hellmann cycle shows a range of 16 per cent., and probably more.

The Hellmann curve in the Arizona pines is given in Fig. 11j. This is derived from 3,000 measures in 58 trees, distributed across two hundred miles of country, approximately including 1850 to 1905; the cyclogram, Fig. 8j, uses the interval 1825 to 1920. A 19-year cycle lasting since 1800 completely dominates the record. This was removed by mathematical methods and also a 14-year cycle, whereupon the Hellmann cycle was well marked in the curve. It shows a lag of two or three years in relation to sunspot phase. It should be added that some of the individual groups in this large assemblage of trees, such as the one from the Grand Canyon, give the Hellmann cycle in prominent form without the interfering cycles.

Fig. 8k shows Grand Canyon tree growth from seven trees, 1825 to 1920. The effect is here shown of using the center of gravity of the maxima. It produces a Hellmann cycle of very good form. There is the same probable two or three year lag, as in the general Arizona curve. A lag of -3 or -4 years fits many of the curves very well.

Fig. 8l, as already mentioned, gives the sunspot numbers with an inversion of minimum values for comparison with the Hellmann cycles from terrestrial

sources. For method of reading the cyclograms, see note at end of paper.

This concludes the presentation of the Hellmann cycle in trees. At this point two notes should be made. First, this cycle is common in trees since 1850 and, second, the interfering cycles, 14 and 19 years, are widely distributed cycles. The shorter one is plainly a solar cycle, as will appear later, and the longer is probably so.

II. Historical Changes in Hellmann Cycle

Having described a cycle in tree growth that has the same length as the sunspot cycle, but usually of different shape, it is well to see if any historic changes in this cycle can assist us in deciding on its identity. In 1909, two years before exact dating was developed, a trace of Hellmann cycle was noted in the Arizona pines. In the next three years a remarkable example of Hellmann cycle was found on the wood in rings 1430 to 1530 or later. The two-crested form was noted, lasting with some interference to near 1650. There it stopped, but was resumed again later. This is shown in Fig. 12. An 11-year cycle reappeared after 1725, but it did not resume the regular Hellmann type till after 1800. Even then it was partially hidden by interfering cycles. The complete failure of the 11-year cycle during the interval from 1660 to 1725 caused at the time much doubt of any significance in the apparent relationship to the solar cycle. All this was published in 1919, with full reference to the failure near 1700. In 1922 Maunder published an article on the great dearth of sunspots from 1645 to 1715, and gave me my first information regarding that phenomenon. During the dearth, sunspots were very rare; two intervals of 10 years and four or five of 5 years show no sunspot records at all. Under such conditions it is quite evident that estimates of sunspot minima have no value and dates of maxima are none too good, for very large spots may come at almost any time in the cycle. This coincidence between the failure of spots and the failure of the 11-year cycle in trees was a source of great interest to Dr. Maunder and myself and greatly strengthened the solar explanation of the Hellmann cycle in trees.

On the occasion of publishing some account of this in 1928, it seemed worth while to find what cycles, if any, replaced the 11-year cycle in tree growth. The Arizona trees answered at once with a 10-year cycle. Four sequoias, which generally seemed to show more 11-year cycles than the others, gave a plain 10-year cycle during the dearth of sunspots. Many sequoias showed cycles also at 8.5 and about 14 years. A long hemlock record in Vermont gave 20 and 28 years with probable half values at 10 and 14.

So it seemed necessary to examine the sunspot record with more care, to find how it compared with these results. The maxima assigned by Wolfer were plotted and analyzed, and it was evident that a 10-year cycle between 1615 and 1788 would fit as well as the usually accepted 11-year cycle. On trying it out the average residual is just about the same. But if one uses Wolfer's weights, as of course one should, the average residual decreases 25 per cent., thus giving some preference to the 10-year cycle and producing agreement with the tree records.

All this is exceedingly difficult to show in the form of a plot or diagram, because with the exception of the cyclogram method, used since 1913 in these studies, there is no adequate way of representing the mixtures, the changes, the continuities or the interruptions of cycles in a single plot. I am therefore showing in Fig. 13 a certain form of plot specially adapted to presenting cycles. It gives on ordinary rectangular coordinates the residuals between an exact

cycle and the observed cycle. If the residuals are constant the plotted points form a horizontal line. If in any part of the diagram the residuals are changing at constant rate, they must form a straight slanting line. But any set of residuals changing at constant rate is merely expressing a cycle of different length. Thus the direction taken by any row of plotted points becomes a measure of cycle length. This is the important feature and to such a plot the name of cyclogram is given. So in Fig. 13 in plots 1 and 2 the horizontal alignment in the right half, mostly since 1800, represents the 11-year sunspot cycle. Before 1800 the line is on a slant pointing (if it were on a clock dial) toward 2 o'clock. This indicates a 10-year cycle. The 1 o'clock line is an $8\frac{1}{2}$-year cycle. The 5 o'clock line is a 14-year cycle.

The uppermost of the four plots produces a characteristic Hellmann effect by including sunspot minima as well as maxima (See also Fig. 8*l*). The 10-year cycle effect in the left half is more conspicuous than in the second line giving sunspot maxima only. The second plot shows the alternative possibilities of 10 and 11-year cycles in the maxima. Plot 3 gives the obvious 10-year effect in Arizona pines from 1600 to 1800. And the fourth shows a similar plot of the eleven sequoias, whose measures were published in 1919. Here the 10-year cycle is faint, but $8\frac{1}{2}$ and 14-year cycles are very clear. While these cycle values appeared during the dearth of sunspots, they appear at other times also and can not be considered as specially characteristic of that solar condition. The characteristic of that time is the absence of the 11-year cycle in tree records that show it before and after.

Fig. 14 presents the same facts in a less elegant but better known form. Here the tree record indicated by a solid line begins two hundred years before the sunspot record indicated by a dotted line. The Hellmann cycle shows strongly in those two centuries. This is followed by a 10-year cycle in tree and sun during the dearth interval. In the last hundred years the agreement is resumed on the 11.4-year basis. Thus in the dominant cycles, 10 and 11 years, the trees change with the sun. The minor cycles, $8\frac{1}{2}$ and 14 years, are generally present in each. The presence of these cycles in the sun is shown independently by the cyclogram process, and by Schuster's periodogram, as will appear in the next part of this paper.

In summarizing this section upon historical changes in the Hellmann cycle two items should be noted. First, after having traced the Hellmann cycle through the 1400's and 1500's, into the 1600's when sunspots were well seen, we find that it disappeared when there was a great dearth of sunspots, and reappeared when the spots came back. During the dearth there existed in the trees three solar cycles, of which the 10-year cycle was prominent in the trees and probably in the sun. This historical agreement between trees and sun offers the second definite argument that solar changes do influence tree growth.

The second note is this: To change these residual plots into the best cyclogram form as used for years, it is only necessary to add one or more duplicates of the plotted points at proper spacing below. It then became possible to trace alignments of residuals over much greater range and several differing cycles can be seen at once in the form of lines pointing different ways, and beginnings and endings may be determined as well as variations, discontinuities and change of phase. In full cyclogram analysis this diagram is produced automatically and can be varied in continuous progression over a wide range of cycle lengths. It should be carefully realized that cyclogram treatment does not exclude mathematical treatment, it precedes it; that is, it tells where the mathematical study is best applied.[1]

[1] The inadequacy of harmonic analysis may be illustrated in this way. Suppose we have a

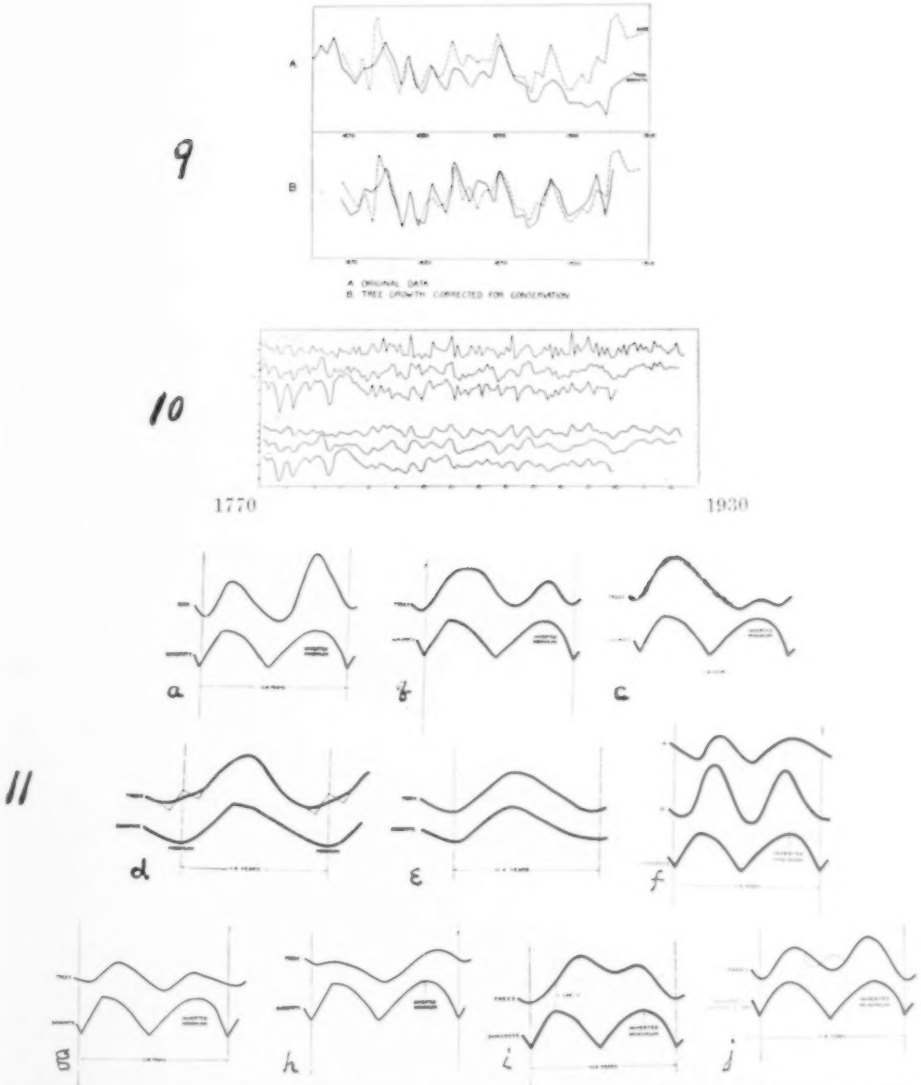

PLATE 3: 9. PRESCOTT TREE GROWTH AND RAINFALL, REGION OF LOWER FOREST LIMIT. (PUBLISHED *ibid.* PG. 68.) 10. UPPER THREE CURVES SHOW LYNCH'S RAINFALL INDICES, 1770–1930; SAN BERNARDINO MOUNTAIN PINE RECORD AND UPLAND SEQUOIA RECORD: LOWER CURVES ARE THE SAME SMOOTHED. 11. HELLMANN CYCLES OBTAINED BY INTEGRATION OF DATA USED IN FIGURE 8; SEE TEXT; CORRESPONDING SUNSPOT PHASE IS SHOWN IN LOWER CURVE.

III. Cycles in Past Climates

A third group of results gives added weight to the probabilities of a solar relationship brought out in the last topic. It deals with the more general question: What groups of cycles are found in tree records, and are they related in any way to solar cycles?

Forty-two groups of western pine, 305 trees with 52,000 measures, have given us by analysis a large number of cycles (published in 1928). Each analysis was checked by independent tests on inverted curves and altered time scales. It was noted as early as 1926 that the cycles were distinctly grouped about values that bore simple ratios to the 11-year sunspot cycle. This was published in 1928 (January) and the more finished results appeared in 1929 in "Conferences on Cycles," issued by the Carnegie Institution. In the month of the first publication, C. E. P. Brooks published a result of similar nature derived from the Nile Gauge Readings. Clayton, a little later, noted the unexpected great relative importance of simple fractions of the 11-year solar cycle, and Abbot has dealt with radiation varying in short-cycle lengths, similarly connected with the solar cycle.

Cycles obtained in modern tree ring records are indicated in Fig. 15, upper line. They are 8½, 10, 11.4, 13.5, to 14.5, 17 and 19 and others still longer.

At Flagstaff, Arizona, in 1904 the writer discovered in an arroyo a tree stump in place that had been buried 16 feet below the top of the valley terrace. In 1919 and for several years after, with especial help from Major L. F. Brady, a large number of tree sections were secured from different depths between 1½ feet and 16 feet. The annual rings in the logs at shallow depth were of the sort now growing in the pines thereabouts—dry climate rings. The rings at 12 and 16 feet in depth were wet climate rings, large and showing a slow surge in size characteristic of continuous water supply. This contrast occurring in one locality appeared to indicate a climatic change. Ten of these buried trees, chiefly from the upper levels, gave excellent measured records aggregating more than 1,400 years. Here again we found cycle values near 8½, 9.6, 14, 17 and 19, and especially the Hellmann double-crested cycle averaging 11.4 years (see Fig. 15, second line).

The very remarkable clay records revealed by Professor Gerard DeGeer in Sweden and Dr. E. Antevs in North America well deserve careful analysis for cycles. Antevs' measures of the clay layers in the Connecticut Valley, left in the retreat of the New England ice sheet, received a brief preliminary analysis soon after they were published and a recent fairly complete review. His sequence, examined for cycles, covers about 4,000 years with a break in it. Careful cross-dating has no doubt given the separate parts a fine continuity. Cycles were frequently recognized between 7 and 8 years in length, shown in the third curve of Fig. 16. At 8.8 and at 10 there were strong cycles. The 11-year cycle is weak or absent. Only two good examples of it were found in the 4,000 years. A cycle appeared at 12.5 years, a group at 13 and 14.5, some at 16 and 17, and strong cycles close to 20 years. This result is essentially repeated in the 736 years of Hudson River varves recently published by Dr. Chester A. Reeds, of New York.

In 1912 a large number of fragments of swamp cypress, *Taxodium distichum*, described to me as Pleistocene, were secured in the peat beds north of Dresden.

five-year cycle lasting for twenty years. If we pick out just that twenty years, harmonic analysis will show that cycle; if we try forty years, such analysis can only give the cycle at one half amplitude; if we have one hundred years of data the amplitude is only one fifth of the real value. One sees that this effect is exactly opposite to the effect on permanent astronomical cycles, which are strengthened by increasing length of data.

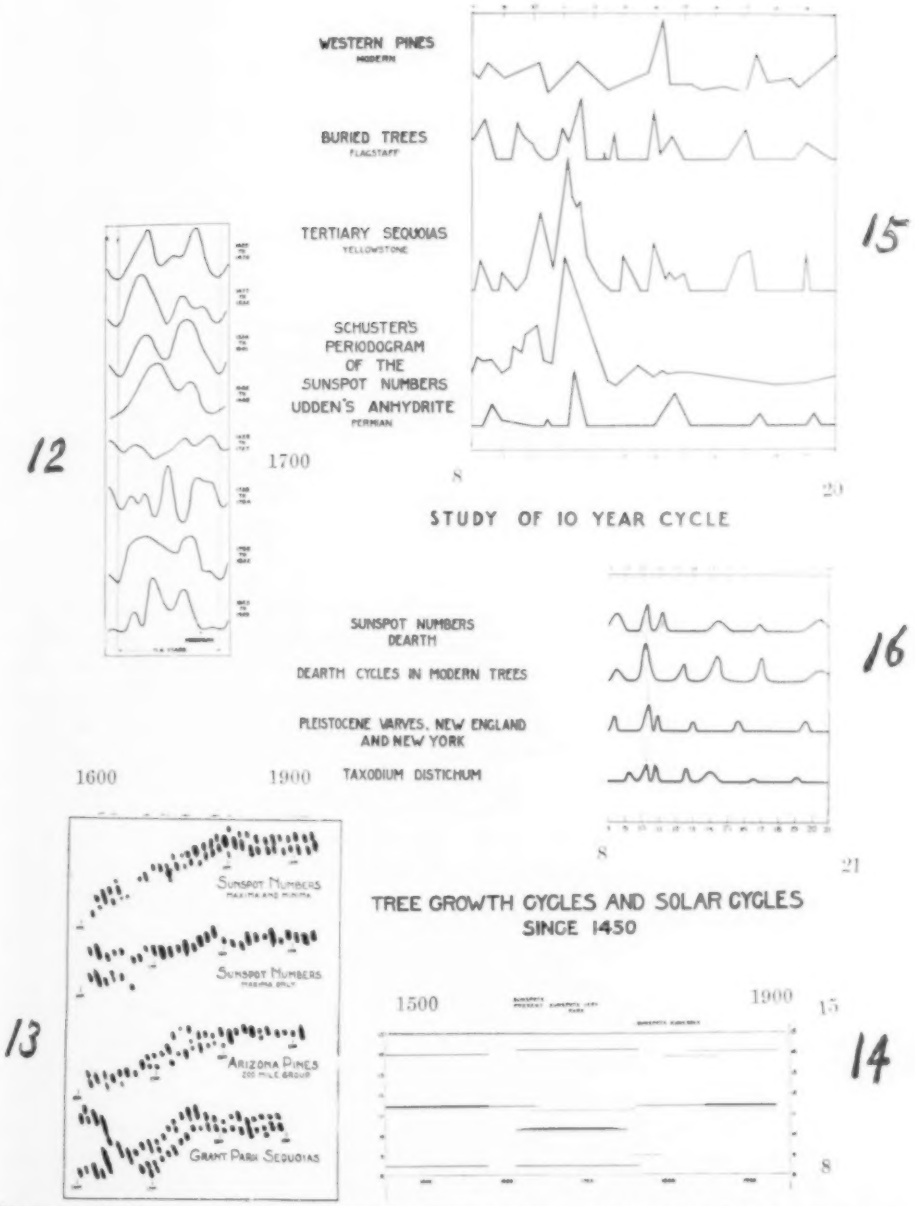

PLATE 4: 12. HELLMANN CYCLE IN ARIZONA PINES AND ITS ABSENCE NEAR 1700 IN DEARTH OF SUNSPOTS; THESE CURVES WERE PUBLISHED IN SAME VOL. I, PG. 103; THE LAST THREE SHOW INTERFERENCE OF OTHER CYCLES. 13. "RESIDUAL PLOTS," CYCLOGRAM TYPE, SHOWING DEARTH CYCLES, 1650–1750, AT 8½, 10 AND 14 YEARS. 14. SAME PLOTTED IN TERMS OF CYCLE LENGTH AND TIME. 15. GEOLOGIC CYCLES COMPARED WITH SCHUSTER'S PERIODOGRAM OF THE SUNSPOT NUMBERS. 16. CYCLES IN ICE AGE MATERIAL COMPARED TO DEARTH CYCLES IN SUN AND TREES.

The total rings measured were 1,260 in number, distributed in four specimens giving long sequences of rings that appeared to be nearly free from errors. One five hundred year record gave a strong cycle at 10.9 years; another gave a good cycle at 10.0 years. Others were not particularly satisfactory, owing to the complacency of the growth. There are here some items of resemblance to the varve cycles just described (see Fig. 16, lowest curve).

In 1929 and 1930 collection was made of some 38 tertiary sequoias, silicified, from Specimen Ridge in the Yellowstone National Park, with results shown in the third curve of Fig. 15. These fossils were largely secured by Messrs. Mason and Reade as far as possible from one single horizon of petrified stumps. Probably many of them were living trees at the same time. Like the corresponding species to-day, the coast redwood, they are cross-dated with difficulty, for there are no distinctive drought rings to serve as guides, as in the giant sequoias and the pines of dryer regions. The counting therefore lacks the precision of cross-dated material, but yet is thought not likely to have errors that would change the results. So each tree record was counted carefully by Mr. H. F. Davis, over 11,000 rings measured, plotted and analyzed by him. This resulted in a surprising number of cycles between 11 and 12 years. I have personally repeated the analyses and have confirmed the frequency of the prominent Hellmann cycle at 11.2 to 11.8 and the usual cycles at 8½, 10, 14, 17 and 19. Some of the sequences gave groups of cycles so closely alike that it may be possible to cross-date by that means. That is a new problem to be tested later.

Several years ago the late Professor Udden, of the University of Texas, discovered lamination in anhydrite material forming a drill core brought up from some 1,500 feet in depth in Culberson County, Texas. He became satisfied of the annual character of the layers and by aid of a grant from the Carnegie Institution caused them to be measured. He thought there might be an error of the order of 2 per cent. in layers lost. The longest good sequence of layers studied has 1,443 years. The measures were turned over to Dr. E. L. Dodd for cycle analysis. He made a report showing the presence of cycles at 10, 11, 19 and 33 years. I was fortunate enough to secure a copy of this series of measures and have checked the analysis and confirm Dr. Dodd's results. I find cycles at 7 to 7.5 years, 8.8, a very prominent Hellmann cycle at 11.4, a group between 14 and 15 years, a faint one at 17.5 years and a little better one at 19 years. I found only a weak cycle at 10 years, as shown in Fig. 15, last curve.

These various analyses of modern and past climates when brought together show two chief results of interest to us. First, all these terrestrial cycles from modern trees and geological sources approximate in length the cycles in sunspot numbers (see Fig. 15, fourth curve), and second, they exhibit the two types of cycle complex or mixture already observed historically in the sun and trees, namely, the present common type, dominated by an 11.4 year cycle, and the dearth type, containing a 10-year cycle with about the same minor cycles in each group. The first of these types is shown in Fig. 15. This figure brings out the agreement found in modern trees, in buried trees, living perhaps 2,000 years ago, in Miocene sequoias from Yellowstone Park, in Udden's Permian anhydrite from Texas, with Schuster's periodogram of the sunspot numbers—an evident similarity outlining an immense interval of time.

But there is evidence that this cycle complex was not continuous from Permian times to the present, for the Pleistocene varves and logs of swamp cypress, *Taxodium distichum*, probably of the same age, give the dearth cycles of sun

and trees. Fig. 16 shows the cycles in sun and trees from 1600 to 1750, and below, the varve and cypress cycles. One notes that these Pleistocene cycles resemble the terrestrial and solar cycles near 1700 A. D., when there were many successive years without sunspots.

In this review of cycles in past climates it seems difficult to avoid the conclusion that these terrestrial cycles are connected with solar cycles. At the same time we get an idea of stability in the source of these cycles, even though the terrestrial results are sometimes complex.

IV. Characteristics in Climatic Cycles

Attention should be called to the general resemblance between tree growth and solar cycles in their discontinuous or fragmentary character. When examined in cyclograms they look alike, save that the recent solar record is more apt to have only one cycle at a time. Before 1800, however, it had a mixture. The solar cycle is discontinuous, made up of substantial fragments. At the time of its discovery, somewhat less than one hundred years ago, it must have seemed very unstable, as a century of changes had just taken place: four cycles at about 9 years each, after 1750, then three cycles averaging 14 years, then one at 7, and then one or two at 11, but since that time it has been very constant at about 11.4 years.

Cycles in trees and climate seem apt to display similar changes, but they also display more cycles at one time, thus causing confusion. This may be persistence of cycles after the cause has changed, possibly a biological character. The cause may be persistence of cycles in the sun in some form less conspicuous than the usual smoothed annual sunspot numbers. Records in trees are very subject to a strong 2-year variation in which successive years tend to present opposite extremes. A similar character in weather has often been discussed, and similarity may be found to the cycle of 25 months quoted by Abbot in his solar radiation work. We must remember that cycles of two or three units are the most frequent to occur in accidental data. An approximate two-year cycle could be the cause of the great scattering of individual yearly values in rainfall and tree growth. In a large part of the analyses here quoted, the tree record has first been smoothed by a very simple formula $N=\frac{(n-1)+2n+(n+1)}{4}$, which nearly eliminates the 2-year variation and gives an opportunity for longer cycles between 5 and 35 years to be observed.

Extensive testing work has been done to find if the long tree records can be distinguished from accidents and it is found that they can be so distinguished, if 150 or 200 years in length. The first criterion is the presence of a greater number of long cycles. This establishes a different type of periodogram from accidental sequences in which increasing prominence is given to the shorter cycles.

We find in terrestrial records certain long cycles that result from interference between short solar cycles already mentioned. In the solar records we have the Hellmann cycle and also a cycle at 8½ years; the interference time between these two is 34 years, which gives us the Brückner cycle, frequently observed in tree growth. It is mentioned by Dr. Dodd as present in Udden's anhydrite measures from Texas. The interference between 14-year cycles and 11.4 is about 57 years. The Arizona trees show a strong cycle of this length between 1170 and 1500 A. D. The interference between the most common values of the 10 and 11-year cycles (about 10.3 and 11.4) is closely 100 years. This cycle was noted by Michelson in his analysis of the sunspot numbers. Many years ago it was found by the writer in Hunt-

ington's measures of the big sequoias as very prominent for nearly 2,000 years. Later it has been confirmed, but not specially studied, in accurately dated sequoia records. In the 1,200-year Arizona pine record a 100-year cycle is very prominent, indeed. All these scattering items sustain the idea of a relationship between the changes in the sun and the cycles in tree growth.

V. Conclusion and Comment

The dating and measurement of the 250,000 annual rings of trees and the application to them of improved forms of cycle approach and an assured climatic interpretation of tree growth lead us to view climatic cycles as real cycles, distinguishable from accidents if shown in long sequences; appearing in a mixture of three or four cycles, long since found in sunspot records. The cycles seem to be discontinuous but occur in substantial fragments. Of these the most important is the Hellmann cycle, which in accordance with the evidence given above is considered to be a terrestrial reaction to forces operating in the body of the sun and caused through the agency of solar radiation.

In lack of a line of physical causation the relationship here stated is based on circumstantial evidence, but that evidence is very strong and a physical relationship through radiation is entirely reasonable. In fact, in these days it is not denied by any one that solar changes must effect terrestrial conditions; it is merely felt that such effects are too small to be found. The result of these tree ring investigations then shows that such effects are sometimes large enough to appear extensively in the growth of trees.

If climatic and tree growth cycles are discontinuous, can they be made of value in prediction? The answering thought is that long-range prediction, if possible, is far in the future. We must first know the actual climatic cycles as they are and then discover, also, the factors that bear upon their interruption. A considerable number of beginnings and endings seem to be associated with the centennial disturbance above referred to. In regard to shorter cycles a considerable number have been found to begin or end at sunspot minimum or maximum, with a probable preference for the minimum. Yet sometimes a short cycle passes through a minimum without change. Important information on this subject will be found in the immensely long records of the giant sequoias. The Hellmann cycle, and other cycles that seem to be associated with it, reappear at various times in the last 3,000 years. When these various recurrences are analyzed for a major cycle, some length of the order of 280 years has seemed to apply successfully. This particular study has received the name of "cycle succession."

It must be fully recognized that thus far we have dealt with very limited parts of the world. There are, for example, stores of information in our southern forests. We know practically nothing of the tree reaction in the southern hemisphere. Fine groups have been obtained from near the northern Arctic Circle, but not yet accurately studied. It is perfectly evident that the distribution about the earth of the effects of radiation from the sun must be very complex. Yet I can not agree with the meteorologists who consider that the complexity of this distribution accounts for all climatic changes. I think, on the contrary, it is a question of hard work to find regions in the world whose climatic changes can most easily be related to solar influence, and then persistent work is needed to understand the regions that are more complex. Perhaps some regions are too complex ever to give satisfactory solution, but as a better idea is developed of the nature of solar and terrestrial changes, we will be able to gather together data bearing upon world

changes. Probably it is another problem like that of distribution of tides.

Lastly, the next obvious step is to develop the biological reaction, the relation of ring width to environment and especially to climatic elements. It is true that there are some localities where a single element, like rainfall, dominates the growth, but even here other factors have influence and in most cases the interaction is very complex.

Upon the heels of this development we must have a mathematical technique specially adapted to the study of temporary and double-crested cycles; and finally an urgent need, and one difficult to satisfy, lies in the increased development of knowledge of the physics and mechanics of the solar atmosphere.

Method of Reading Cyclograms

The method of reading cyclograms may be illustrated by an enlargement of Fig. 8 *g* and 8 *m*. Here, as in all cyclograms, each dot represents a full crest in the original curve whose analysis produced the diagram. The cyclograph, or analyzing instrument, is so constructed that, when set to analyze at a certain cycle length, the primary alignment of dots will be horizontal if the curve contains that cycle length (Fig. 8 *m*, A–A′). Simply for advantage to the eye, the primary row of dots is repeated two or more times in each pattern (Fig. 8 *m*, A–A′ and A–A′). Now if a faint row of dots (B–B′) appears between the main horizontal rows it means that two crests in the curve rather than one represent the particular period at which the analyzing was done. The entire series of diagrams in Fig. 8 was photographed with the cyclograph set at 11.4 years. Hence one may readily see not only that the 11.4-year cycle is present and dominant but also that in the majority of cases it possesses two crests which, by definition, represent the Hellmann cycle.

If the curve under analysis possesses a period different in length from the one at which the instrument was set, its presence will be revealed by an oblique or secondary alignment (Fig. 8 *m*, C–C′). The row of dots, D–D′, indicates the double-crested nature of the cycle represented by C–C′. In fact, the slant downward to the right in Figs. 8 *g* and 8 *m*, as well as in *h*, *i*, *j*, *k* and *l*, is caused by a double-crested 14-year cycle which, it is evident, exists both in the tree records and in the sunspot numbers.

MARCO POLO AND SOME MODERN THINGS OLD IN THE ASIA OF HIS DAY

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THE MAN

MARCO POLO (1254–1325 or '26) was 15 years old when his father (Nicolo) and uncle (Maffeo Polo) returned to Venice in 1269 from their first visit to the East. When the brothers left Venice on their first trip is not known, but in 1260 they were in Constantinople on a trading venture and from there they traversed central Asia to the court of Kublai Kaan in Mongolia. On their second journey Marco Polo accompanied them. They left Venice in 1271 and after a journey across Asia of about three and a half years reached the court of the great emperor in 1275. Kublai received the elders very cordially and seems to have formed an especial liking for Marco, who was then about 21 years old. Marco was taken into the service of the Kaan and served in local administrative positions and was also sent on distant missions over almost the whole of Kublai's empire. He found that Kublai was interested not only in administrative matters but also in a wide knowledge of the peoples of his great empire, their lives as influenced by their environments, their industries and commerce, the natural history of their provinces, etc. These matters Marco seems to have noted either in writing (according to Ramusio) or in his memory, and the reports he made to Kublai had no small part in determining his high standing with the emperor. Indeed, in chapter xvi of the Prologue to Marco's book, Kublai is quoted as saying of the young Venetian, when he returned from a mission to Yun-nan, that "If this young man live, he will assuredly come to be a person of great worth and ability." Later, out of these notes and memories, was constructed one of the greatest travel books of the world.

The Polos remained in China so long that they doubtless feared that the great Kaan or his successor would never let them go. In 1292, Kublai desired to send the Lady Kokachin of his court as wife to his nephew Arghun, Khan of Persia, and when the long inland route seemed too hard for the tender 17-year-old maiden, and too filled with dangers, the envoys desired to return by sea. But these envoys were not sailors and the Polos were, so it seems that the Persians asked the Kaan to let the Venetians conduct them by water. This was strongly seconded by the Polos, who saw here an opportunity and means to return safely to Venice with their gathered wealth. At last Kublai consented reluctantly, but having done so he fitted the party out lavishly and dismissed the Polos with many royal gifts. And so early in 1292 they left the port of Zayton (Chinchew in Fokien) in 13 ships, with a suite of some 600 persons, not counting the sailors.

The voyage was ill-starred and long, but the Polos and the Lady Kokachin reached Hormuz on the Persian Gulf late in 1293, having lost two of the three envoys and most of their suite on the way. The lady, who parted from them with many tears, was sent to the Persian court and the Polos went to Tabriz and after a long stay there proceeded by way of Constantinople to Venice, which they reached in 1295 or 1296. They had been gone about 24 years [1271–1295 or

1296], 17 of which (1275–1292) had been spent at the court of the Great Kaan. The passage of these years had brought many changes in Venice and in our travelers. According to Ramusio they had difficulty in establishing their identities, but finally they succeeded, and with their wealth the Polos became substantial citizens of Venice.

Of the three, Marco became the most prominent. His accounts of the wonders seen, of the great wealth of Kublai and indeed of all Cathay, and his own display of wealth, led to his being dubbed Marco Milioni and Il Milioni—the millionaire or the man who speaks in millions. Indeed, the court in which he lived was called Corte del Milione, and his house and family the Ca' Milion.

As such a prosperous citizen of Venice, Marco Polo would probably have spent the remainder of his days, and his great book would probably have never been written but for a fortunate internecine war between the two republics, Venice and Genoa, each striving to control the trade of the eastern Mediterranean. This war went on with varying successes for both sides, till in 1298, the Genoese, having won a considerable victory, sent an armada against Venice itself. The Venetians hastily fitted out a fleet to join their forces already out at sea looking for the Genoese. One of these galleys was commanded by the distinguished traveler, Marco Polo.

The fleets met off the island of Curzola on the Dalmatian coast, and in the great battle the Venetians were overwhelmingly defeated. Marco's ship was captured and he was taken prisoner and carried to Genoa where he was thrown in prison. Here he met a fellow-prisoner, a man of considerable literary attainments, Rusticiano of Pisa, whose pen was destined to write Marco Polo's book and make history. Presumably Marco, to while away the weary hours, told Rusticiano of the wonders he had seen, and doubtless Rustician persuaded Il Milione to dictate the account of his travels. However, Marco apparently reinforced his memory during this long narration with his notes, since one chronicler avers that he was permitted to send a messenger to fetch them from his father in Venice. At any rate it is well established that Marco was imprisoned in September or October, 1298, was set free in July, 1299, and was probably back in Venice by October, 1299. But in that 10-month prison interval Rustician had written Messer Marco's story, fortunately for the whole world.

Marco's life, from the time of his return to Venice in 1299 till his death in 1324 or 1325, was that of a well-to-do citizen of his native city. His name is found in the records from time to time but without connotation of anything particularly remarkable or unusual. He was probably buried as he wished in the church of San Lorenzo, but no monument was erected, for to his contemporaries he was but a teller of wild tales which their minds could not take in as having a basis of truth. The church of San Lorenzo was rebuilt from its foundations in 1592 and all traces of the burial vault of our traveler are lost. Further, it may be remarked that no authentic portrait of Marco Polo is extant. Those sometimes seen are all products of the imagination, are efforts of the artists to reproduce the lineaments of the Traveler as each conceived them.

THE BOOK

The man has been dead these 608 years, but his book survives and will so long as time endures. The preponderating evidence is that Rustician wrote the narrative of our medieval Herodotus in French, and very bad French at that. In any case the book had a certain popularity and was presently translated into other languages. Even to-day there are extant about 92 MSS—45 in Latin, 21 in Italian (various dialects), 18 in

French, 6 in German, 1 in Spanish and 1 in Irish—so far as they are known. There are many printed editions, beginning with the German version issued at Nuremberg in 1477. How many editions in all have been issued I can not say—88 had been listed in 1921. Probably this list is far short of the actual number.

Now it should be noted that from the first dawn to the recent past, no credence has been given Il Milione's book—it has by many been considered a parallel work to "The Thousand and One Nights." Further the story is told that, long after Marco's death, in the Venetian Masques there was generally a representative of Marco Milioni who told "big stories" to "tickle the ears of the groundlings." Indeed, one writer says "No faith was put in him because of the extravagant things that he recounted." Further, a contemporary chronicler is quoted that on his death-bed the Traveler was begged by his friends to retract his improbable stories. Indeed, when I was a boy I read Marco Polo, Baron Munchausen and "The Thousand and One Nights"—all on the same level of improbability. Further, in 1878, there was published at Milan "Giulio Verne. I Viaggi di Marco Polo," etc. So even at that late date, in his own country, our Traveler was without honor.

But time and the patient work of scholarly editors have brought the world to a better and truer estimate of the medieval Herodotus, and let it be said in their high praise that much and the best of this work has been done by Englishmen. However, the first edition to be listed is that of G. B. Ramusio in his "Navigationi e Viaggi" of 1559. Most of the alleged facts of Marco Polo's personal history are contained in the preface to the second volume of this Collection. In this preface dated 1553, Ramusio states that these facts came to him from a senator of Venice (Gasparo Malpiero) who in turn had them from his father and grandfather—the latter of whom was of a generation immediately after Marco's and who had lived in a house on the Corte del Milioni. In the same preface Ramusio states, "I have deemed it reasonable to publish his book with the aid of several copies written (as I judge) more than 200 years ago, in a perfectly accurate form, and one vastly more faithful than that in which it has been heretofore read." This version, with its personal details, has been deemed of such value by Yale and Cordier that many parts of it have been set in square brackets in their translation. Some of these will be quoted later. Furthermore, Baldelli-Boni in 1827 republished the Rasmusian version with numerous notes, and Bürck's German edition of 1855 is mainly a translation of Ramusio with notes from Marsden.

In 1818 William Marsden published in London the first great English edition with a valuable introduction and notes. In 1824, the Société de Géographie of Paris published the most valuable manuscript (the one nearest to Rustician's original). This was followed in 1865 by G. Pauthier's learned version, based on the collection of three unpublished manuscripts in the great library of Paris. Then followed in rapid succession in 1871 and 1875 Colonel Henry Yule's first and second editions, in which that learned geographer firmly established Marco Polo's travels to, in and from Cathay as the most extensive and exact of those of any of the medieval travelers. And last of all is the Yule-Cordier edition in two great volumes, containing Yule's notes for a third edition which he did not live to bring out. These were turned over by Yule's daughter to her father's friend, the great Sinologist, Henri Cordier of Paris, who brought out the third edition in 1903. This has been twice reprinted

—the second time in 1921. Those who seek to estimate the character of the man and his book are referred to this great work and particularly to Yule's words on pages 104–116 of the illuminating Introduction. Perhaps it will be well to quote the opening paragraph.

> That Marco Polo has been so universally recognized as the King of Mediaeval Travellers is due rather to the width of his experience, the vast compass of his journeys, and the romantic nature of his personal history, than to transcendent superiority of character and capacity.

Then let the reader peruse on pages 106 and 107 an eloquent summary of what this great traveler *saw* and *did*, and then he will be ready to agree that he *was* the medieval Herodotus, the greatest traveler of the Middle Ages and one of the greatest of all time.

From this great edition, one of the most scholarly works it has ever been my privilege to read and reread, the facts above have been collected and the words of Marco Polo, now to be set out, have been gleaned. But for this work, as fully a marvel of scholarly erudition as Marco's chapters are full of the marvels of the East, these notes of mine would never have been compiled. I envy the man who reads this great work for the first time.

SOME PRESENT-DAY NEW THINGS OLD IN THE ASIA OF MARCO POLO'S DAY

From the great wealth of material in Marco's text and in the wonderfully illuminating notes of Yule and Cordier, it is not easy to choose when one would like to quote so much. As a naturalist, I am of course greatly interested in the multitude of natural history notes—and some one ought some day to collect and publish such notes pertaining to animals —Polo's sheep, *Ovis poli*, for instance. However, I shall herein confine myself to certain practises and discoveries of the people of Polo's day which we moderns have lately rediscovered.

Naval Construction

Tremendous advances have been made in the construction of vessels in the very recent past, but some of these will now be shown to be old in Marco Polo's day.

Multi-masted Vessels: For perhaps hundreds of years the three-masted sailing vessel was considered the *ultima thule* of naval construction. I can remember when four-masted schooners were new and so extraordinary that people went miles to see them. Then came the five-, the six- and last the seven-masted schooner, and the world is now sure that the forest of masts on a vessel's deck will never have an addition.

But Marco Polo in his Prologue or Introduction to his Travels, speaking of the preparations made for the return of Arghun's envoys with the Lady Kokachin, in the charge of the Polos, says in Chapter xvii (Vol. i, p. 34)[1] that: Kublai "then caused thirteen ships to be equipt, each of which had [one deck and] four masts and often spread twelve sails." Again, in Book iii, Chapter i (Vol. ii, p. 249), Marco says, "The ship [in which merchants go to and fro amongst the Isles of India] hath but one rudder,[2] and sometimes they have two additional masts which they ship and unship at pleasure." Yule suggests that one of these was probably a bowsprit, which the Chinese occasionally use.

To work one of these great ships Polo states that 200 men were required—250–260 in the Ramusian version. Further,

[1] This quotation and the others to follow are taken from "The Book of Ser Marco Polo, the Venetian, Concerning the Kingdoms and Marvels of the East." Translated and Edited with Notes by Colonel Sir Henry Yule. . . . Third Edition Revised Throughout in the Light of Recent Discoveries by Henry Cordier (of Paris). London, John Murray, 2 vols. 1921 (third printing). The references are to book and chapter of Marco Polo's own work. For the convenience of the reader the volume and page references to Yule-Cordier are added in parentheses.

[2] Many European vessels of Marco's day had two rudders.

Ramusio states that formerly they used even larger ships than these. When the wind failed, these mariners got out sweeps, four men to a sweep. Again they had sailing tenders, which, with sails or sweeps, towed these great junks out of danger or into port.

Water-tight Compartments: These are supposed to be ultra-modern devices, the last word in modern shipbuilding practise to make sure the safety of our ships. But here is what Cordier interpolates from Ramusio's version, previously referred to. Marco, in Book iii, Chapter i (Vol. ii, pp. 249–250) states that in China:

> Moreover the larger of their vessels have some thirteen compartments or severances in the interior, made with planking strongly framed, in case mayhap the ship should spring a leak, either by running on a rock or by the blow of a hungry whale (as shall betide oft-times, for when the ship in her course by night sends a ripple back alongside the whale, the creature seeing the foam fancies there is something to eat afloat, and makes a rush forward, whereby it often shall stave in some part of the ship).[3] In such case the water that enters the leak flows to the bilge, which is always kept clear; and the mariners having ascertained where the damage is, empty the cargo from that compartment into those adjoining, for the planking is so well fitted that the water cannot pass from one compartment to the other. They then stop the leak and replace the lading.

Planking and Caulking: In these matters, the Chinese of our Traveler's day had anticipated the best modern practise in wooden vessels. Here is what he has to say about it in Book iii, Chapter i (Vol. ii, p. 250):

> The fastenings are all of good iron nails and the sides are double, one plank laid over the other, and caulked outside and in. The planks are not pitched, for these people do not have any pitch, but they daub the sides[4] with another matter, deemed by them far better than pitch; it is this. You see they take some lime and some chopped hemp, and these they knead together with a certain wood-oil; and when the three are thoroughly amalgamated, they hold like any glue. And with this mixture they do paint their ships.

[3] This anticipates "Moby Dick."

[4] Between the planks!

Another practise recalls the extra-planking or sheathing applied to the bows of our tugs in northern harbors where ice abounds in the winter; and applied to the whole hull of a wooden whaling or exploring vessel setting out for the Arctic. Here follow Polo's own words in the book and chapter cited above (Vol. ii, p. 251):

> When the ship has been a year at work and they wish to repair her, they nail on a third plank over the first two, and caulk and pay it well; and when another repair is wanted they nail on yet another plank, and so on year by year as is required. Howbeit, they do this only for a certain number of years, and until there are six thicknesses of planking. When a ship has come to have six planks on her sides, one over the other they take her no more on the high seas, but make use of her for coasting as long as she will last, and then they break her up.

This multiple-planking was necessary after one year's work, because these vessels were made not of solid oak as are ours but of soft fir. It is then conceivable that at the end of a season's use the hull would be pretty well strained and open, and that the easiest method of repair is that indicated. The use of old hulks as coasting barges is strictly parallel with our modern practise.

Sewed Planking: Vessels with sewed or stitched planks are in use if not today then very recently on the Malabar and Coromandel Coasts of India, and I believe also in other parts of the world. Their pliancy makes them of great value as surf boats. But Messer Marco found them in use in his days and he so makes record in Book i, Chapter xix (Vol. i, p. 108), of their use at Hormuz on the Persian Gulf, in these words:

> Their ships are wretched affairs, . . . for they have no iron fastenings, and are only stitched together with twine made from the husk of the Indian nut. They beat this husk until it becomes like horsehair, and from that they spin twine, and with this stitch the planks of the ships together. It keeps well, and is not

corroded by the sea-water, but it will not stand well in a storm.

The Indian nut is evidently the cocoa-nut, as is further made clear from its size (of a man's head) and the description of the white meat and the clear fluid. Incidentally this is the first reference to it known to me in the writings of a European. The beaten husk which becomes like horsehair is evidently the material known to-day as coir.

Rapid Transit

When man progressed beyond the stage of foot travel, it was because he had tamed and made a servant of the horse and its allies. The journey of the Polos across central Asia to the court of Kublai Kaan was done either on horses or on camels. The far-flung conquests of Chinghis and Kublai were brought about by their well-organized armies of horsemen. But even here speed was limited.

Horse-Post Express: In the sixties of the last century, when the Central and Union Pacific Railways were being built across the high mountains and great plains of the United States, the mails were carried from rail-head to rail-head by the famous Pony Express. This rapid transit was effected by having relay and remount stations from 10 to 25 miles apart. Read Mark Twain's "Roughing It" and learn how a light spare rider raced at full tilt into a station and threw himself and the mail bag into the saddle of a fresh mount and was away at a gallop before the saddle was off his old horse. Thus the Pony Express carried the mails from Saint Joseph, Missouri, to Sacramento, a distance of 2,000 miles, in 8 days at a speed of 10 miles per hour and was the marvel of the time.

But the great Kaan had *his* Pony Express 500 years earlier. Thus Marco wrote in Book ii, Chapter xxvi (Vol. i, pp. 433–437) how from the royal city of Cambaluc (Pekin or Peiping) the Kaan had paved highways running to the various provinces. At every 25 miles on these royal roads was a *Yamb*, a "Horse-Post-House" or station, for the care and forwarding of travelers, but especially to expedite the movements of the emperor's messengers. Marco states that there were in the empire more than 10,000 stations and that more than 300,000 horses were kept for the use of these messengers.

To save horse-flesh, foot-runners were generally used. As in India in the recent past if not in the very present, each man was equipped with a belt set with bells to give notice of his coming. Between these post-houses, smaller stations were built every three miles and the runner carried the despatches only that distance and turned them over to the next man. However, in case the despatches called for greater haste and speed, then horses were used. The riders were equipped with bells, as were the foot-runners, and the chronicler thus writes of them (p. 436):

> They take a horse from those at the station which are standing ready saddled, all fresh and in wind, and mount and go at full speed, as hard as they can ride in fact. And when those at the next post hear the bells they get ready another horse and a man equipt in the same way, and he takes over the letter or whatever it be, and is off full-speed to the third station, where again a fresh horse is found all ready, and so the despatch speeds along from post to post, always at full gallop, with regular change of horses. And the speed at which they go is marvellous.

Marco's specific statements as to the speed of these couriers are exaggerated and contradictory. In this chapter he says that the runner will carry despatches from places 10 days off in a day and night and from 100 days distant in 10 days and nights. The horsemen on the other hand will do 200 or 250 miles in a day and as much in a night. Yet he notes that at night they have to go slower because they are accompanied by footmen with torches, and

the rider must accommodate his speed to that of the runner.

Then Marco adds a detail about the dress of the riders, which I think (but am not sure about) was also true of our Pony Riders. Here are his own words: "Those men [riders] are highly prized; and they could never do it, did they not bind hard the stomach, chest and head with strong bands." Had they not done so they would have literally been shaken to pieces. As an indication of how accurate Marco generally was in his observations, in speaking of the paved roads of Manzi as recorded by Ramusio, he meets a query in the reader's mind in the following statement (Book ii, Chapter lxxvii—Vol. ii, p. 189): "But as the Great Kaan's couriers could not gallop their horses over the pavement, the side of the road is left unpaved for their convenience." This, furthermore, is just what is found in the clay "shoulders" alongside our concrete roads in the United States to-day, and these soft shoulders are to-day utilized by horsemen in just the same way in order to save the horses' feet.

Dog Sledges: We have all known for a long time that in the Arctic—in Siberia, Alaska, around Hudson Bay and in Greenland—travel in the winter especially is by dog sledge. A few years ago we were all thrilled over the wonderful dash against time of Balto and his companions to carry diphtheria antitoxin to a stricken town in Alaska. Those of us who live in New York have seen the statue to this great-hearted dog in our Central Park near the old arsenal.

But our old Traveler writes of post dogs in Siberia in his Book iv, Chapter xx (Vol. ii, pp. 479–481). Whether he went there on a mission for the Great Kaan, or whether he got his information from others, can not be said, but his account reads like that of an eye-witness. He speaks of a king in the far north, Conchi by name, a kinsman of Kublai's, whose country was 13 days in extent and quite impossible for horses. Here post-houses were established a day's journey apart with 40 great dogs to draw the couriers from station to station. These worked thus:

> On a sledge they lay a bear-skin on which the courier sits, and the sledge is drawn by six of those big dogs that I spoke of. The dogs have no driver, but go straight for the next post-house, drawing the sledge famously over ice and mire. The keeper of the post-house however also gets on a sledge drawn by dogs, and guides the party by the best and shortest way. And when they arrive at the next station, they find a new relay of dogs and sledges ready to take them on, whilst the old relay turns back; and thus they accomplish the whole journey across that region, always drawn by dogs.

Public Carriages: One of the great conveniences of modern city life is cab service, and, in the present day of motor-cars, especially the taxicab. There is no need to argue this matter, but it may strike the reader as a bit unusual to learn that in the China of Marco Polo's day there were public carriages for hire in many of the great cities. Here is what Messer Marco says in Book ii, Chapter lxxvii (Vol. ii, p. 206) on this subject:

> In the main street of the city of Kinsay (Hangchau) you meet an infinite succession of these [public] carriages passing to and fro. They are long covered vehicles, fitted with curtains and cushions, and affording room for six persons; and they are in constant request for ladies and gentlemen going on parties of pleasure.

Yule remarks in a note that at one time such carriages were much more common in the great cities of the north of China than they are now. They were abandoned in China about the time that they were introduced in the cities of Europe. This disuse may have been either the effect or the cause of the neglect of the roads on which Marco has been quoted. There is no definite statement as to the motive power, but this is implied when he writes that the people are fond of "driving about the city in

carriages." Probably these were something like palanquins.

Sanitary and Hygienic Matters

We of the present day think that we have carried sanitation to such a point of excellence that nothing in the past can measure up to our standards. It will then be of interest to quote Marco Polo on certain precautions which he found in vogue in China.

Mouth and Nose Muffled: In times of influenza epidemics and even when only possessed of a common cold, we are wont to keep mouth and nose covered when coughing and sneezing to prevent transmission of germs. In case of a surgical operation, the precautions taken seem almost exaggerated. The other day I saw a picture of an operating room, with the surgeon in the foreground having his whole face below his eyes covered with a mask. But according to the Preacher in Ecclesiastes "there is nothing new under the sun" as the following quotation from Book ii, Chapter xiii (Vol. i, p. 383) will show:

> And you must know that those who wait upon the Great Kaan with his dishes and drink . . . have the mouth and nose muffled with fine napkins of silk and gold, so that no breath nor odour from their persons should taint the dish or the goblet presented to the Lord.

Sputum Cups: Modern medical and sanitary science has brought us the sputum cup or receptacle for use by those suffering from respiratory diseases, and at sanitariums for tubercular patients its use is *de rigeur*. As to its use in China in the thirteenth century let us hear our old Traveler. He writes in Book ii, Chapter xxxiv (Vol. i, p. 458) thus of the matter of Kublai's court:

> And every one of the chiefs and nobles carries always with him a handsome little vessel to spit in whilst he remain in the Hall of Audience —for no one dares spit on the floor of the hall —and when he hath spitten [in the vessel] he covers it up and puts it aside.

Drinking Cups: Another widely used modern device to prevent the spread of communicable diseases is the individual drinking cup, which is generally thrown away after use. Marco Polo, on his voyage around India with the escort of the Lady Kokachin, found individual drinking cups in use in the province of Maabar (*i.e.*, the Coromandel Coast). Here is his statement (which the editors find in the Ramusian version only) taken from Book iii, Chapter xvii (Vol. ii, p. 342):

> So also they drink only from drinking vessels, and every man hath his own; nor will anyone drink from another's vessel. And when they drink they do not put the vessel to the lips, but hold it aloft and let the drink spout into the mouth. No one would on any account touch the vessel with his mouth, nor give a stranger drink with it. But if the stranger have no vessel of his own they will pour the drink into his hands and he may thus drink from his hands as from a cup.

Suspended Beds: At the Marine Biological Laboratory of the Carnegie Institution of Washington at Tortugas, Florida, to prevent the inroads of omnipresent ants, we slept on cots suspended by iron rods passing through tin cups filled with kerosene oil. This is a common present-day practise in tropical countries to prevent attacks by various insect enemies and to secure better ventilation. A like device was found in use in Maabar by Marco Polo. In his Book iii, Chapter xvii (Vol. ii, p. 346), interpolated by Cordier from Ramusio's version, is the following account:

> The men of this country have their beds made of very light canework, so arranged that, when they have got in and are going to sleep, they are drawn up by cords nearly to the ceiling and fixed there for the night. This is done to get out of the way of tarantulas which give terrible bites as well as of fleas and such vermin, and at the same time to get as much air as possible in the great heat which prevails in that region. Not that everybody does this, but only the nobles and great folks, for the others sleep in the streets.

Ventilators: Ventilation in hot countries, especially at night to help induce

sleep, is a matter of prime importance. Among the devices invented to meet this need is the coolie-operated punkah of India and our own efficient electrically driven fans. At Hormos on the Arabian Sea our medieval Herodotus writes in Book iii, Chapter xl (Vol. ii, p. 452) that:

> The heat is tremendous, and on that account their houses are built with ventilators to catch the wind. These ventilators are placed on the side from which the wind comes, and they bring the wind down into the house to cool it. But for this the heat would be utterly unbearable.

Yule has an interesting note on these ventilators, which he calls "a kind of masonry windsail." He notes that such are common to-day throughout parts of Egypt, Mesopotamia, Persia and northern India, and he figures such a device from Persia. The reader who is sufficiently interested will find Yule's discussion in Vol. ii, pp. 452–453.

There is a present-day form of condenser for compound condensing steam engines called a cooling tower which works on this same principle. A tower open at top and bottom contains a multitude of pipes filled with steam from the low pressure cylinder. Over these pipes cool water trickles, is evaporated by the heat, and the vapor rises and passes out at the top, creating a current. Again, as in ice factories, the steam pipes with trickling water are simply placed on the roof for the wind to play over them.

Gold Teeth: The matter now to be considered is only remotely connected with the general heading above, but it does have some connection and it is so unusual and so interesting that it will be set forth last of all for this section.

One of the notable discoveries of modern prosthetic dentistry is the gold crown (and the bridge also) and its use to preserve badly decayed teeth, which left uncovered would not hold their fillings, and very soft teeth which would break down without such reinforcement. But our Venetian tells us in Book ii, Chapter i (Vol. ii, p. 84) that in the province called Zardandan:

> The people of this country have all their teeth gilt; or rather every man covers his teeth with a sort of golden case made to fit them, both the upper teeth and the under.

Zardandan is a Persian word meaning "gold-teeth." The province is near the head-waters of the Mekong river. Whether the gold-teeth of these people were single crowns or a collective covered-bridge-like structure can not be said. The latter is probable. A later describer of these people says that they take the gold case off when they eat. However, in 1800, Marsden and also Raffles found the people of Sumatra using this casing, "sometimes indented to the shape of the teeth," and not removing it when eating or sleeping. Whatever interpretation we put on this device, it is certainly an approach to the present-day crown, the modern "gold-tooth."

Building, Clothing, etc.

Marco Polo notes many things of interest under these heads, but it is difficult to segregate those which are old and yet new. However, some remarks of his about the uses of the bamboo, which he calls the "cane," may be of interest. This plant is of universal distribution throughout the East, and Marco notes three uses in his book.

Bamboo Buildings and Roofs: Throughout the Indian Archipelago to-day, houses are made of split bamboo and are roofed with bamboo tiles. Ser Marco tells us in his Book i, Chapter lxi (Vol. i, p. 299) that Kublai built in his pleasure park at Chandu (Kaipingfu) a summer palace of "cane." The roof is of especial interest and is thus described—the part in square brackets being taken from Ramusio:

> The roof, like the rest, is formed of canes, covered with a varnish so strong and excellent that no amount of rain will rot them. These canes are a good 3 palms in girth and from 10

to 15 paces in length. [They are cut across at each knob, and the pieces are split so as to form from each two hollow tiles, and with these the house is roofed; only every such tile of cane has to be nailed down to prevent the wind from lifting it.]

It is notable that the describer does not say how the "joints" are "broken" by a third tile. Two tiles are laid side by side, concave surfaces up, and their two adjacent edges are covered by the third laid with the convex surface up. This is just the arrangement which one sees in all pictures of Chinese roofs to-day.

Bamboo Ropes: In China to-day, cables and tow-lines used by river-boats and "tracking" lines on the Yangtse are made of bamboo. Presumably the first mention of them is that in Messer Marco's Book ii, Chapter lxxi (Vol. ii, p. 171). Speaking of travel on the river Kian (Yang-tse-Kiang), he states that:

You must know that the vessels on this river in going up-stream have to be tracked, for the current is so strong that they could not make head in any other manner. Now the tow-line, which is some 300 paces in length, is made of nothing but cane. 'Tis this way: they have those great canes of which I told you before that they are some fifteen paces in length; these they take and split from end to end [into many slender strips], and then they twist these strips together so as to make a rope of any length they please. And the ropes so made are stronger than if they were made of hemp.

Exploding Bamboos: The matter now to be considered concerns a use of the bamboo which is apparently the first on record. One can hardly read a book of travel and exploration in the East in which it is not recorded that the travelers put green joints of the bamboo on their fires in order that the explosions may drive away wild beasts. Here is what our Traveler says on the subject in writing of the province of Tebet in his Book ii, Chap. xlv (Vol. ii, p. 43). It should be noted first that Mangu Khan, Kublai's elder brother, had literally laid waste this province, with the result that bamboos had grown up everywhere, and ravenous wild beasts had so enormously multiplied as to make it very dangerous to traverse the country. Marco has this to say about this use of bamboos in this region:

And let me tell you that merchants and other travellers through that country are wont at nightfall to gather these canes and make fires of them; for as they burn they make such loud reports that the lions [*i.e. tigers*] and bears are frightened, and make off as fast as possible; in fact nothing will induce them to come nigh a fire of the sort. . . . I will tell you how it is that the canes make such a noise. The people cut green canes, of which there are vast numbers, and set fire to a heap at once. After they have been burning awhile they burst asunder, and this makes such a loud report that you might hear it ten miles off.

Bark Cloth: When the first voyagers traversed the South Seas, they found the natives making cloth of the bark of a tree and using it for clothing. Nor has this custom entirely died out yet. Further we read that during the Great War the Germans made and wore paper clothes. This is essentially the same thing. But Marco Polo found bark cloth used in the China of the late 1200s. His account unfortunately is very brief and entirely devoid of details. He says in Book ii, Chapter lix (Vol. ii, p. 124) in speaking of the people of Cuiju (Kwei-chau) that: "You must know they manufacture stuffs of the inner bark of certain trees which form very fine summer clothing."

Agriculture, Stock-Raising and Food Production

Marco Polo mentions four such matters, which, in addition to being probably first records, are of sufficient interest to be noted.

Huskless Barley: Barley is a cereal which seems to have originated in western Asia where it has been cultivated from the earliest times. It is the hardiest of the grains and has the highest range both in altitude and latitude.

Among the desiderata of plant breeders to-day are grains devoid of "beards" or pointed husks. Such get into the clothes of the laborers in grain fields, and when eaten by farm animals may cause considerable trouble. The Encyclopedia Britannica records the fact that there are two huskless species but without definitely assigning a habitat. They seem to be Asiatic in origin and possibly Himalayan. But our old Traveler states that in his day there was found a huskless form in the province of Badashan, north of Afghanistan (Book i, Chapter xxix; Vol. i, p. 158).

Hybrids of Yak and Cow: The yak, both wild and domesticated, is found in Central Asia. The wild forms are much larger and stronger than the tame ones. I do not know if any modern attempts have been made to cross them with cattle, but Ramusio makes Marco say in Book i, Chapter lvii (Vol. i, p. 274) that in the kingdom of Erguiul (not identified): "They cross these [yaks] with the common cow, and the cattle from this cross are wonderful beasts, and better for work than other animals." I do not know, but I suspect that this is the first record of a man-made hybrid between mammals. A recent man-made mammal hybrid is the cattalo—a cross between the domestic cow and the buffalo. It has the hardihood of the buffalo and the good beef-producing qualities of domesticated cattle.

Milk and Its Products: The sanitary production and handling of milk and its products are among the triumphs of modern hygiene. In my morning paper I to-day read an advertisement of milk cultured with *Bacillus acidophilus.* To-day we have various kinds of milk and a great variety of cheeses first sterilized and then cultured with particular kinds of bacteria and molds (in the cheeses only) in order to produce distinctive products with particular flavors.

Now *Kumiz,* or as he wrote it *Kemiz,* had been known long before Marco Polo's day—its first mention seems to be found in Herodotus (Book iv, Chapter ii, of Rawlinson's translation)—but Marco's narrative brought it to the attention of western Europe. He writes in his Book i, Chapter liii (Vol. i, p. 259) of the Tartars that "Their drink is mare's milk, prepared in such a way that you would take it for white wine; and a right good drink it is, called by them Kemiz."

For full details about the preparation and use of *Kumiz* see Yule's interesting notes in Book i, pp. 259–260. Of especial interest just here is the following quotation from the opening paragraph of his notes:

> Fresh mare's milk is put in a well-seasoned bottle-necked vessel of horse-skin [Yule gives a figure of this]; a little *Kurut* [sour buttermilk left after churning] or some sour cow's milk is added; and when acetous fermentation is commencing it is violently churned with a peculiar staff which constantly stands in the vessel. This interrupts fermentation and introduces a quantity of air into the liquid. . . . After three or four days the drink is ready.

Kurut, another milk product, was as staple a food among the Tartars as *Kumiz* was a drink. On this point, in his next chapter, our medieval Herodotus tells how the Tartars in their warfare make long forced marches carrying a minimum of supplies. The chief of these is a "dried milk," or *Kurut,* as it was called, in the preparation and use of which the Tartars seem to have long anticipated our modern evaporated milk. Messer Marco describes both preparation and use in his Book i, Chapter liv (Vol. i, p. 262) in the following phraseology:

> They also have milk dried into a kind of paste to carry with them; and when they need food they put this in water, and beat it up till it dissolves, and then drink it. [It is prepared in this way; they boil the milk, and when the rich part floats on the top they skim it into another vessel, and of that they make butter; for the milk will not become solid till this is removed. Then they put the milk in the sun to dry. And when they go on an expedition, every man takes some ten pounds of this dried

milk with him. And of a morning he will take a half pound of it and put it in his leather bottle, with as much water as he pleases. So, as he rides along, the milk-paste and the water in the bottle get well churned together into a kind of pap, and that makes his dinner].

Sago Flour: How early sago flour was made in the east and when its use came to the knowledge of Europeans can not be said. But Ser Marco, on his voyage around Sumatra, found it being made and used in the Kingdom of Lambri. Here read his words from Book iii, Chapter xi (Vol. ii, p. 300):

They have a kind of trees that produce flour, and excellent flour it is for food. These trees are very tall and thick, but have a very thin bark, and inside the bark they are crammed with flour.

Notable is the bare statement utterly devoid of details. However, Messer Marco certainly saw the sago flour being made, for in Ramusio's version the details of its manufacturing are given and it is stated that Polo brought some of the bread home with him to Venice. This Ramusian account Yule gives in full (Vol. ii, p. 305) and below it Cordier (in the third edition) has quoted A. R. Wallace's almost parallel account from his "Malay Archipelago." It is plain that each account is that of an eye-witness.

Governmental Affairs

The empire of Chingis Kaan and of his successors (his sons and grandsons) covered practically the whole of Asia and even included southeastern Europe. His aim seems to have been to subjugate the whole world, and before his death, its extent did include half the human race. Of this great realm, of which, in the day of the Polos, Kublai was at least the nominal head, Yule writes thus: "In Asia and Eastern Europe scarcely a dog might bark without Mongol leave, from the borders of Poland and the Gulf of Scanderoon to the Amur and the Yellow Sea."

It would be interesting to dig out of our old Traveler's book a great variety of notes on the way in which this great empire was administered, but space will only permit reference to two matters in which our practises of the present day were anticipated.

Paper Money: One of the prime necessities in this great empire was a universal currency and one of which large amounts could be easily transported. This Kublai met by manufacturing and issuing paper money "so light that ten bezants' worth does not weigh one gold bezant." In his Book ii, Chapter xxiv (Vol. i, pp. 423–426) Ser Marco writes most interestingly of Kublai's "Mint, . . . in the which he hath his money coined and struck." This seems such an improbable matter that he adds . . . "tell it how I might, you would never be satisfied that I was keeping in truth and reason." His speaking of the millions of money issued from the "Mint" of Kublai is probably one of the things that led to Marco Polo's being called "Il Milione" in Venice years later.

This paper money was made of the bark of the "Mulberry Tree." Its production is thus described by the Chronicler:

What they take is a certain fine white bast or skin which lies between the wood of the tree and the thick outer bark, and this they make into something resembling sheets of paper, but black. When these sheets have been prepared they are cut up into pieces of different sizes. The smallest of these sizes is worth a half tornesel; the next, a little larger, one tornesel; one, a little larger still, is worth half a silver groat of Venice; another a whole groat; others yet two groats, and ten groats. There is also a kind worth one Bezant of gold, and others of three Bezants, and so up to ten. All these pieces of paper are [issued] with as much solemnity and authority as if they were of pure gold or silver; and on every piece a variety of officials, whose duty it is, have to write their names, and to put their seals. And when all is prepared duly, the chief officer deputed by the Kaan smears the Seal entrusted to him with vermilion, and impresses it on the paper, so that the form of the Seal remains printed upon it in red; the Money is then authentic. Any

one forging it would be punished with death.] And the Kaan causes every year to be made such a vast quantity of this money, which costs him nothing, that it must equal in amount all the treasure in the world.

This Mongol paper currency had no metallic basis and of course underwent great fluctuations. Furthermore, it was not the first issue in China. Yule states that the use of paper money there goes back to the sixth century, that the first Mongol issues were in 1236, while Kublai's extended from 1260 till his death (1294). For a discussion of these issues and their fluctuations in value, see Yule's and Cordier's erudite notes (vol. i, pp. 426–430). These issues of paper currency without any metallic basis have a parallel in many propositions of to-day (1933) to inflate the currency of the United States by the simple expedient of using a printing press.

Fire Alarms: One of the functions of local government is the detection and extinguishing of fires. The traveler through New England, New York, New Jersey and Pennsylvania will frequently see in the villages a primitive, inexpensive and efficient fire alarm apparatus. This consists simply of a heavy wagon tire, or better still a locomotive tire, sawn in two at one place and the ends at the cut sprung apart for better resonance. Hanging by a chain is a hammer. The deep booming sounds from the struck tire summon the villagers to help put out the fire.

It is interesting to find that the Chinese had devised and were using essentially the same apparatus in Marco Polo's day. In his Book ii, Chapter lxvi (Vol. ii, p. 189) in speaking of the governing of the city of Kinsay (Hangchau) Marco states that:

Within the city there is an eminence on which stands a Tower, and at the top of the tower is hung a slab of wood. Whenever fire or any other alarm breaks out in the city a man who stands there with a mallet in his hand beats upon the slab, making a noise that is heard to a great distance. So when the blows upon this slab are heard, everybody is aware that fire has broken out, or that there is some other cause for alarm.

In Cambaluc (Pekin) Kublai had a high tower with a bell in it to give alarm when struck. However, this was used primarily to strike the hours and for a curfew signal. This curfew matter was, moreover, not new to the Polos, since their Venice and all other European cities had had such a law for a long time. William the Conqueror brought the curfew law to England.

Miscellaneous Matters

There are a few other matters described by Marco which do not fit in any of the sections above, but which are of sufficient interest to merit brief mention.

Block-Printing: The question whether or not Marco Polo had anything to do with the introduction of block-printing into Europe is one that has been much debated. Yule has shown the inaccuracy of these contentions (Introduction, Vol. i, pp. 138–141). In short, there is no evidence that our Traveler did anything of the kind. However, he certainly brought back the information that block-printing was known in his time in China, for the paper money described above was certainly printed from blocks and then the seal was applied by means of another block. This conclusion I draw from Yule's reproduction (to face p. 426, Vol. ii) in two colors of a banknote of the Ming Dynasty. None of Kublai's currency seems to have survived, but as indicated some has been preserved from the Ming which followed immediately (1368) after the Mongol rule.

Docking Horses' Tails: In my boyhood in the mountains of West North Carolina, in winter and with bottomless roads, travel was almost wholly on horseback. On such roads a horse's tail would soon become loaded with mud and in cold weather this would soon freeze.

Hence it was the custom to tie or knot the tail high up. Later came the practise of bobbing the tails of horses, partly for the reason given but largely to give the horses a smart appearance. This was all right in winter, but was a great deprivation to the animal in fly-time. However, it did save the rider a great deal of annoyance, as I can testify.

Probably this is an old and widespread practise, and doubtless well known to those who study the evolutions of customs and habits of mankind, since similar needs lead to the development of similar processes and practises among people widely separated. At any rate it was a familiar thing in the China of Messer Marco's day, as we may read in his Book ii, Chapter xlix (Vol. ii, p. 78). In speaking of the people of the Province of Carajan (in Yun-nan in the upper Irrawadi valley), he says, "And you must know that the people dock two or three joints of the tail from their horses, to prevent them from flipping the riders, a thing which they consider unseemly."

Cooking at High Altitudes: It is of course widely known nowadays that at great altitudes it is difficult to cook foods by boiling, since water under diminished pressure boils at too low a temperature. While crossing the Pamir, the "Roof of the World," Ser Marco found (Book i, Chapter xxxii, Vol. i, p. 171) that the region was very lofty and cold and adds, "I must notice also that because of this great cold, fire does not burn so brightly, nor give out so much heat as usual, nor does it cook food so effectually." So far as I know this is the earliest record of a fact on which Humboldt and many others have later written most interestingly. It is another proof of our Traveler's keen observation.

Manufacture of Pygmies and Mermaids: On their trip around southeastern Asia with Arghun Khan's envoys and the Lady Kokachin, the Polos visited Java and our Herodotus gives this interesting statement about the manufacture of pygmies. It is found in Book iii, Chapter ix (Vol. ii, pp. 285–286).

> I may tell you moreover that when people bring home pygmies which they allege to come from India, 'tis all a lie and a cheat. For those little men, as they call them, are manufactured on this Island, and I will tell you how. You see there is on the Island a kind of monkey which is very small, and has a face just like a man's. They take these, and pluck out all the hair except the hair of the beard and on the breast, and then they dry them and stuff them and daub them with saffron and other things until they look like men. But you see it is all a cheat; for nowhere in India nor anywhere else in the world were there ever men seen so small as these pretended pygmies.

These pygmies I suggest are the forerunners of the "mermaids" of later times, the manufacture of which was at one time carried on in the seaports of southeastern Asia. The late Dr. F. A. Lucas once told me that in his early voyages to China, Indo-China, Sumatra, and Java (in the middle sixties of the last century) these mermaids were on sale in these ports and that many ship captains brought home specimens. Indeed once in a space of three years two specimens were brought to my office in the American Museum. These "genuine" fabricated mermaids were made by grafting on to the torso of a small dried monkey the tail of a dried fish. Scales were so skilfully introduced among the hairs and hairs among the scales, that on one specimen it was difficult to say where monkey left off and fish began. One of the specimens referred to was so perfect and its owner was so solid in his belief that it was a natural and not an artificial product and hence priceless, that he was all broken up when I demonstrated the facts to him. I may add that it was Dr. Lucas' opinion also that Marco Polo's pygmies were the forerunners of the modern "mermaid."

This article grows long, but there are still left many things that one would like to mention. Then there is opportunity for a most interesting article on his "firsts"—first mention of this or that—a few of which will be mentioned. Thus he is probably the first to make mention of ancient astronomical instruments when he speaks of "a kind of astrolabe on which are inscribed the planetary signs, the hours and critical points of the whole year" found in the city of Cambaluc (Pekin).

Again when sailing around the island of "Seilan," Marco saw and described the fishing for pearls in the gulf of "Bettelar." And he does not fail to make mention of "those men who charm the great fishes [sharks], to prevent them from injuring the divers." This I believe to be the first mention of the men of this profession, who still make incantations to protect the pearl-divers of the present day in these same waters.

Strabo and many later writers tell us of the Ichthyophagi at the head of the Persian Gulf. Furthermore, some of these tell us that there the cattle also feed on fishes, but Marco is the first (and I believe the only one) to state that "The cattle will also readily eat these fish alive and just out of the water."

That babies are sometimes born with tails (prolongations of the spinal column) are facts well known to medical men and surgeons. There are nearly 100 cases on record in the medical literature. But whether there are races of tailed men is another matter, and one of great interest to physical anthropologists, for since the days of Ptolemy and Ctesias, they have been alleged to dwell in southeastern Asia, in the East Indies and in Melanesia. I do not know if the Herodotus of classical times tells of them, but his medieval successor does. These he heard of in the kingdom of Lambri (on Sumatra).

Some time and labor have been spent in the preparation of this article, but much has been learned and if the reading of these notes will incite others to read and study and learn from this magnificently scholarly edition by Yule and Cordier of the marvels seen and reported by our old Traveler, my labor will have been well spent.

AMPHICEPHALOUS REPTILES

ANIMALS REPUTED TO HAVE A HEAD AT EACH END OF THE BODY[1]

By Professor BERT CUNNINGHAM

PROFESSOR OF BIOLOGY, DUKE UNIVERSITY

MONSTERS, animals having abnormalities, have always held a strange fascination for man. Those occurring among lower animals have been the source of much of our mythology, while those occurring among humans have given rise to some of our demonology.

While there are many authentic monsters of strange and bizarre appearance, many others are figments of the imagination which are either remotely based upon fact or are wholly without foundation. It is difficult to determine the origin of some of the ideas, and their wide-spread appearance seems to argue against a common source.

Among recurring stories concerning reptiles is one which portrays animals with two heads, one at each end of the body. In this paper such animals are called amphicephala. It is my purpose to examine such reports and to determine, if possible, their bases.

Animals of the foregoing type, whether mythical or not, were early called by the group name Amphisbaena, and stories concerning them range from the days of Nicander (185–135 B.C.) to recent times, and in regions as widely separated as Europe, Asia, Africa and Mexico, and also the United States. However, it is doubtful if any modern scientist believes in the existence of such monsters.

If one were forced to select animals in which such phenomena might occur, one would most naturally select worms and snakes, and it is here, for the most part, that one finds such records and traditions. Except for a single mention of the condition in worms, the reports thus far found center upon the reptiles and include three of the four common orders of reptiles, namely, serpents, lizards and turtles.

SNAKES

It is not at all surprising that most of the reports of amphicephalic animals, or animals that closely approach this condition, should relate to reptiles, since among them are two groups of animals without legs which have certain characteristic habits that lend aid to the deception on which such ideas may be based. There are certain snakes (*Cylindrophis rufus* and others) which are described and figured (see Fig. 1) by Barbour[2] as running with the tail erect, and, in some cases, swaying it back and forth. Such specimens would serve as exceptional evidence, to the superficial observer, of a snake which seems to be crawling backwards. It follows naturally, therefore, that this snake is capable of crawling in both directions, and amphicephala are thus created from misinformation. There are also legless lizards whose bodies are nearly uniform in diameter throughout the whole length and whose eyes and mouths are very inconspicuous. These lizards move with celerity either backward or forward and often run with the tail erected, which give them somewhat of the appearance of snakes crawling with heads raised from the ground. The general character of this group of animals may be better understood by examining Fig. 2, which is a photographic copy of the drawing

[1] The writer is especially indebted to Dr. E. W. Gudger, of the American Museum of Natural History, for many helpful suggestions during the preparation of this paper.

[2] T. Barbour, "Reptiles and Amphibians." Op. p. 48. Boston. 1926.

of *Amphisbaena alba* from Leunis.[3] To lizards of this group the name Amphisbaena has been applied in modern literature, and, in order to avoid confusion, it is proposed in this paper to use the word Amphicephala to indicate specimens which are presumed to have a head at each end of the body. This term was used by Galen in describing Amphisbaena, which was thought by him, as well as by Nicander, to be amphicephalous.

Nicander,[4] in so far as I have been able to discover, is among the first, if not the first, to describe an amphicephalous reptile. In the original Greek he uses the term "amphicarenus," which likewise means "having a head at each end." He writes (verse 372 *f*) as follows:

> You find the amphisbaena to be small and slow, with a head at each end, always dim in its vision, for a blunt (or rounded) chin is extended out over the eyes at each end. The color is, as it were, of the earth, with a skin of changeful hue, spotted all over. When it comes to maturity, the wood-cutters of the mountains, after cutting a branch of wild olive as a staff, strip off the skin of the amphisbaena when it makes its first appearance, before the cry of the cuckoo in spring. The skin benefits those who suffer from numbness in their hands when bitten by the frost and icy cold, or those who suffer from exhaustion when tense nerves are relaxed and fingers grow weary.[5]

The comment on this passage in the Scholia (p. 30) is as follows:

> The amphisbaena is a small and sluggish snake with a head at each end, and dim-sighted on account of the thickness of its chins. In color it is earthy, variegated with small spots. Whenever the wood cutters come upon and kill this snake, they put the skin around a staff and dry it and keep it as a remedy for fatigue and for numbness from colds.

The "chins" evidently are small folds of skin on the front of the head, which may be seen in Fig. 2. With these descriptions, one has no difficulty in recognizing the animal as an amphisbaena, and also that it is in no sense amphicephalous.

Although Nicander was a toxicologist of recognized repute, he attributed no evil effects to the presence of these animals. In time, however, the Amphicephala began to acquire a bad reputation, so much so that when Pliny[6] wrote, he described them as follows:

> The amphisbaena (Amphicephala) has two heads, that is to say, it has a second one at the tail, as if one mouth were too little to discharge all its venom.

In Book 5, he cites further dangers of this reptile, but luckily suggests methods by which disastrous results may be avoided He writes:

> If a pregnant woman step over a viper, she will be sure to miscarry; the same, too, in the case of Amphisbaena, but only when it is dead. If, however, a woman carries about her a live amphisbaena in a box, she may step over one with impunity, even though it (presumably the Amphisbaena) be dead. An Amphisbaena preserved for the purpose will insure an easy delivery. It is truly a marvelous fact, but if a pregnant woman steps over one of these serpents that has not been preserved, it will be perfectly harmless provided she immediately step over another that has been preserved.

The reputation of this reptile must have reached a peak with Pliny, for although Lucan (30–65 A.D.), in his "Pharsalia," clearly states the existence of the creature, he does not dwell upon its deadliness at any length. The editor's (Hoskins') note on line 719 reads:

> deadly amphisbaena tapering to two heads, *i.e.*, it was supposed to have a head at each end of its body and so be able to move equally in both directions.

Two hundred years later, Aelianus[7]

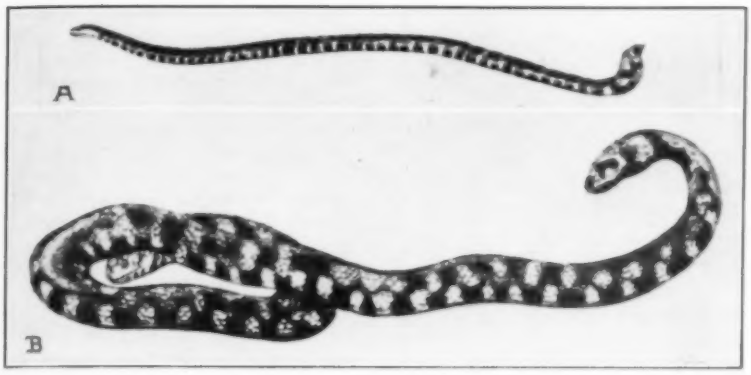
[3] J. Leunis, "Synopsis der Thierkunde," 3rd ed., Vol. 1, p. 571, Fig. 430. 1883.

[4] O. Schneider, "Nicandrea Theriaca et Alexipharmaca." Lipsiae. 1886.

[5] Translation by Dr. C. W. Peppler, Greek Department, Duke University.

[6] Pliny, "Natural History." Translation by Bostock and Riley. Bk. 8, Chap. 35.

[7] Claudius Aelianus, 250 A.D. (*circ*) "De Natura Animalium." Bk. 16, Chap. 42; Bk. 9, Chap. 23.



After Barbour, 1926.

FIG. 1. A. PHOTOGRAPH OF A SNAKE RUNNING WITH TAIL ERECTED. B. PHOTOGRAPH OF THE SAME SNAKE AT REST.

REPRODUCED BY PERMISSION OF PUBLISHER.

places amphicephalous animals among the fabulous creatures. The idea, however, that amphicephalous animals exist was hard to destroy, and, evidently during the middle ages, as shown above, it again gained ascendency.

In 1536 Cube[8] presented a figure, presumably of this type of animal. His drawing is presented here as Fig. 3. It is rather difficult to determine whether this is really meant to be a figure of an amphicephalon or two separate snake-like animals, with closely applied tails. However, since it is an insert alongside the description of amphisbaena, one may assume it is meant to illustrate the phenomenon. The author does not claim to have seen any specimens, and he refers to descriptions by Isidore, Pliny and Jorath. The latter (an Oriental of the twelfth century whose writings seem to have disappeared), among other things, according to Cube, says: "The amphisbaena . . . is watchful and careful about its eggs, especially when incubating them. For, while one part of it sleeps,

[8] J. von Cube, 1536. Hortus Sanitatis, Quatuor Libris. Argentorati. (N.B. The first edition which appeared in 1517 has not been accessible).

After Leunis, 1883.

FIG. 2. THE WORM-LIZARD, *AMPHISBAENA ALBA*

THIS IS A LEGLESS LIZARD AND IS THE TYPE OF ANIMAL MEANT BY THE MODERN WRITER WHEN HE REFERS TO AMPHISBAENA.

After Cube, 1536.

FIG. 3. EARLY FIGURE OF AN AMPHICEPHALIC ANIMAL

THIS IS PRESUMABLY A SNAKE, AND IS PROBABLY THE OLDEST FIGURE OF THIS PHENOMENON.

the other keeps watch." The similarity of this figure to the one produced by Hernandez (see Fig. 5), who quotes a statement similar to the above, may suggest the source of the Hernandez figure.

The reports of this type of animal reached the climax during the seventeenth century, and, as usual, two schools were formed—those who believed and those who denied. Weird tales were brought in by many explorers, and mention of such monsters is made in many of the standard books of travel. Fabri[9] not only believed in the occurrence, but thought they represent a distinct species. He says:

> amphisbaena, a little beast . . . For what exceeds the limit of nature and the rank and file of created things than to paint or even fashion, much less to behold a living animal with two heads—not in one place, a thing seen sufficiently often in monstrosities, but one where the tail usually is, and this is not fortuitous either through fault of a sporting or erring mother nature, or in a joke, but by a serious plan in that in the entire species of animal it is accustomed to happen; a thing which most serious authors maintain happens in the amphisbaena.

Fabri does not attempt to figure the monster, but does append a figure of the true Amphisbaena from Paris, which most certainly does not show a head at each end of the body, as may be seen from our Fig. 4.

Although Hernandez[10] did not believe in amphicephalic snakes, he thinks that he should describe a form of which he had heard through a friend. The latter had in his possession a drawing done in color of an amphicephalous reptile which he said had been given him by a man who had made the drawing from a specimen which apparently had originated in Mexico. The figure from Hernandez' text is reproduced here as Fig. 5. From it one is unable to locate this specimen in any order of reptiles. Hernandez thinks that these animals are mythical;

[9] J. Fabri, "Animalia Mexicana," p. 729. Rome, 1628.

[10] A. F. Hernandez, "Nova Plantarum Animalium et Mineralium Mexicanorum Historia." Rome, 1651.

FIG. 4. AMPHISBAENA ACCORDING TO FABRI (1628)

THIS CERTAINLY DOES NOT APPEAR TO BE AN AMPHICEPHALON.

however, he notes that the "Hortus Sanitatis" says that Amphicephala incubate their eggs and that the two heads take their turn in keeping watch over them.

Browne,[11] who seeks to destroy all error, finds the reports hard to believe, and finally says that if such monsters do occur, "they are beside the intentions of nature."

Vernatti,[12] in reply to an inquiry concerning the occurrence of these creatures, writes:

> There are indeed such serpents in these parts (Java Major) which have a head at each end of the body, called Capracapella. They are esteemed sacred by these people, and fortunate to those in whose houses and lands they are found, but pernicious to whomsoever doth harm them. I would have sent one but could get no man who would kill one of them.

Herrera,[13] describing the animals of the new world, states:

> The rattlesnakes are very poisonous as are those having two mouths, the one at the head and the other at the tail, and bite with both; they are white and very short, and persons that are bit by them live only a few hours.

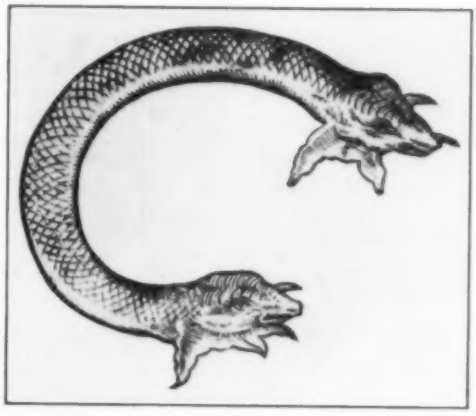


FIG. 5. HERNANDEZ' AMPHISBAENA (AMPHICEPHALON)—1651

THIS FIGURE PURPORTS TO HAVE BEEN DRAWN FROM A LIVING SPECIMEN FROM MEXICO.

Thus far the stories concerning serpents have been hearsay, and apparently none of the foregoing have been eyewitnesses of this type of monster. However, in 1679, a catalog of the Swammerdam[14] collection was published, in which, among other curious creatures, was listed an *Amphisbaena serpens*. In the following year, Blancartus[15] commented on this specimen as follows:

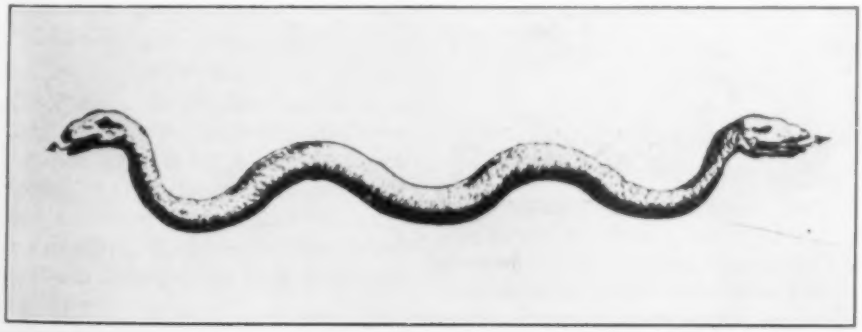
[11] Sir Thomas Browne, "Pseudoxie Epidemica." London, 1669.

[12] Sir Philip Vernatti. "Answer 5. Philosophical Transactions, giving some account of the present undertakings, studies and labors of the ingenious in many considerable parts of the world." Vol. 3, p. 863, 1667.

[13] Antonio de Herrera y Tordesillas, "The General History of the Vast Continent and Islands of America, commonly called the West Indies, from the First Discovery thereof." Translation by John Stevens. Vol. 4; p. 97. London, 1725–1726.

[14] Jan Swammerdam, "Catalogus Musei exhibens curiosam suppellectilem variarum rerum exotic." P. 37, Amstelodami, 1679.

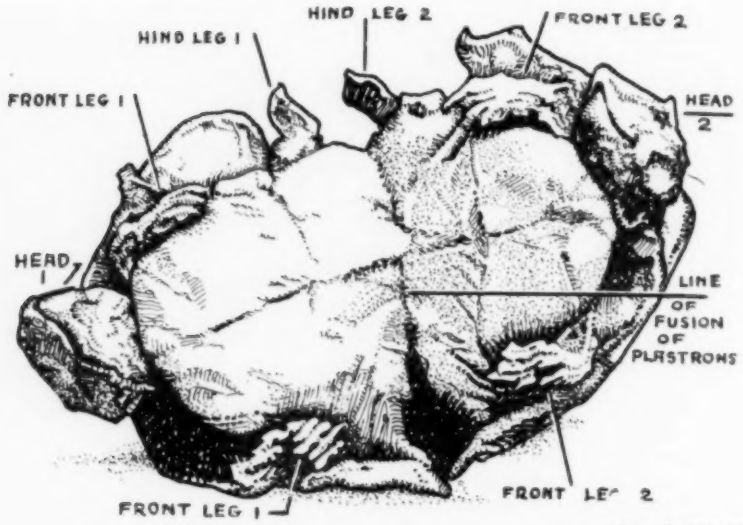
[15] B. S. Blancartus, (Blankaart), Observation 20. Collectanea Medico-Physica, Oft Holland Jaar-Register Der Genees-en Natuur-



After Blancartus, 1680.

FIG. 6. SWAMMERDAM'S AMPHICEPHALON

THIS SPECIMEN IS SAID TO HAVE BELONGED TO THE COLLECTION OF SWAMMERDAM IN AMSTERDAM.



After Townsend, 1928.

FIG. 7. A TURTLE WHICH APPROACHES AMPHICEPHALY

TWO TURTLES FUSED POSTERIORLY, WITH TAIL LACKING. REDRAWN FROM HALF-TONE FIGURE IN THE BULLETIN OF THE N. Y. ZOOLOGICAL SOCIETY.

Some may not believe in two-headed snakes, but they do actually exist, for I have actually handled one which is among the Swammerdam rarities. The specimen is a span and a half long, normal in color, and has a head on each end of the body with small scales.

The figure which accompanied his report is reproduced herewith as Fig. 6. There can be no doubt about what he aims to show. This case is of exceedingly great interest, since two reputable scientists and a well-known scientific publication are involved. Furthermore, if this specimen did actually exist, it must stand alone, as no other cases of exactly this type have been found in the considerable literature that has been examined.

Taken as a whole, it would seem that all the cases reported in reptiles, with the exception of Blancartus, might easily be explained upon some other basis, and, since in no case are they observations of eye-witnesses, they may at least be held in grave doubt, if not totally rejected. The case of Blancartus, on the other hand, must be considered, since an actual specimen in the collection of a scientist, observed by a scientist, and recorded in a scientific publication, can not be ignored, even though one is justified in wishing for additional confirmation.

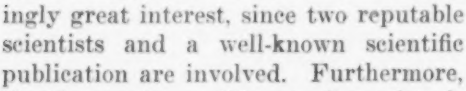


FIG. 8. A DOUBLE TURTLE

A TWO-HEADED TURTLE ERRONEOUSLY FIGURED AS AMPHICEPHALIC, BY ROBERT RIPLEY IN HIS SYNDICATED NEWSPAPER COLUMN "BELIEVE IT OR NOT," 1931.

kundige Aanmerikingen vangantsch Europa. Cent. 1, p. 29, fig. 68. Amsterdam, 1680.

TURTLES

The occurrence of amphicephalous monsters is not incredible. Twins, among humans, have been found fused together in almost every conceivable position, and, among turtles, a case has been reported which approaches, although it does not parallel, the condition described by Blancartus for the snakes.

Townsend[16] has figured a pair of

[16] C. H. Townsend, "A Double Turtle." *N. Y. Zool. Soc.* 31: 35–36, 4 figs. 1928.

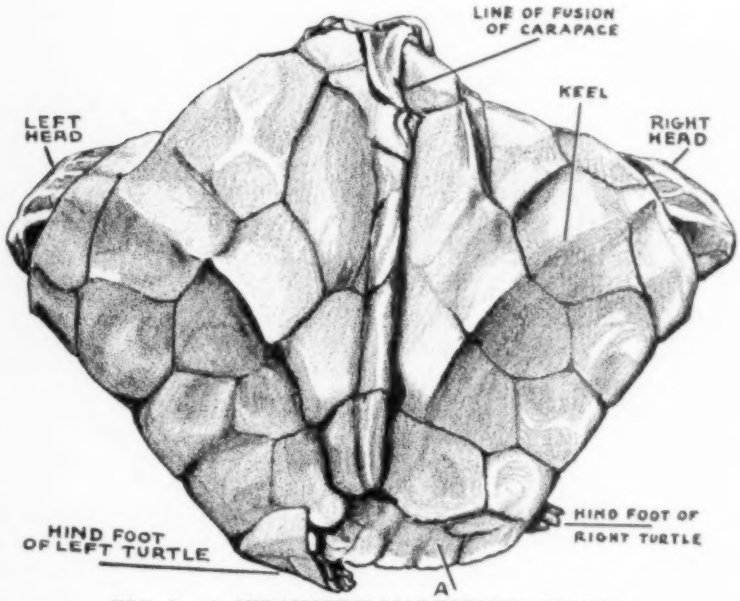


FIG. 9. A STRANGELY MALFORMED TURTLE

DORSAL VIEW OF THE CARAPACE OF THE MONSTER SHOWN IN FIG. 8 DRAWN FROM THE PHOTOGRAPH. ORIGINAL DRAWING.

turtles which were fused together at the posterior ends of the carapace. This figure is reproduced here as Fig. 7. If the two posterior ends of the serpent twins should become grafted in a similar manner but with a little more efficiency, just such a condition as that described by Blancartus would arise. Such an animal might well grow to hatching size, be hatched and live for a few days, even in the complete absence of an anus. The occurrence would naturally be exceedingly rare, possibly even more so than our present records indicate.

It is unfortunate that this specimen figured by Townsend is not available for x-raying, since that would determine whether or not the fusion extended to the skeletal structures.

There recently occurred a figure in Ripley's "Believe it or Not," of a reputed amphicephalous turtle in the possession of a citizen of this state (North Carolina), which is reproduced here as Fig. 8. The source of the "information" on which this figure is constructed is unknown, but the owner of the specimen, who unfortunately had

FIG. 10. OUTLINE DRAWING OF X-RAY OF MALFORMED TURTLE

THE TWO VERTEBRAL COLUMNS, TWO SKULLS, SIX LEGS, TWO SETS OF RIBS, AND THE TWO PECTORAL GIRDLES ARE QUITE EVIDENT. THE PELVIC GIRDLE APPEARS SINGLE BUT SLIGHTLY MALFORMED. DRAWN FROM A PHOTOGRAPH BY THE X-RAY DEPARTMENT OF DUKE UNIVERSITY MEDICAL SCHOOL. SAME SPECIMEN AS FIG. 9. ORIGINAL DRAWING.

loaned it to a show, when shown this picture, wrote me as follows:

> What was in the paper was not right. The animal is about the size of a dollar, has two heads, six legs and two tails.

Later I have been able to recover the specimen and, although it is considerably the worse for wear, I have been able to study the carapace, plastron and skeletal structure. The internal organs were not studied, as external examination indicated that they had probably disintegrated.

The specimen was taken alive by Mr. H. E. Haithcock on a creek bank near Cedar Falls, N. C., in the latter part of January, 1931. It was kept alive until the following June, when it was given into the custody of a traveling show. Some time between then and January, 1932, the animal died and was preserved.

The specimen had evidently hatched during the preceding season and was probably undersized, as it is considerably smaller than the newly hatched specimens of turtles. The measurement from tip of snouts is a little less than four cm. The other proportions are evident in the drawings.

The heads are almost diametrically opposed (see Fig. 9), as figured by Ripley, but in every other detail his figure is erroneous. The tails lie in a line almost perpendicular to the two heads. This has been brought about by a curvature of the vertebral columns. The base of the tail appears single in the external view while the posterior end is branched. The x-ray, however, reveals the true structure. There are two separate tails, in so far as caudal vertebrae are concerned, which cross each other, forming an X. In Fig. 10 an outline drawing of the bony structures is presented, based upon x-ray photographs. While the forelegs of both animals seem to be normal in structure and in number, each animal has but a single hind leg. From the x-ray, it also appears that the fusion is in the pelvic region and that the inner hind legs are eliminated in both specimens. The outer hind legs which are present seem to be normal as to structure.

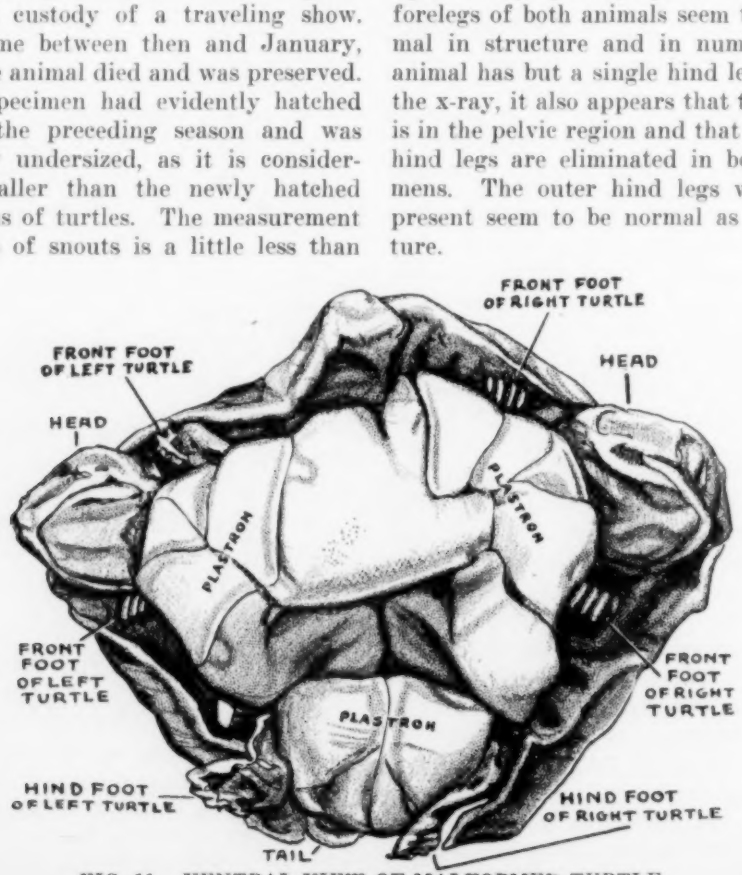


FIG. 11. VENTRAL VIEW OF MALFORMED TURTLE

SAME SPECIMEN AS SHOWN IN FIG. 9, DRAWN FROM PHOTOGRAPH. ORIGINAL DRAWING.

After Aldrovandi, 1637.

FIG. 12. VIEW OF A TWO-BODIED, TWO-HEADED LIZARD

DESCRIBED AND FIGURED BY TORQUATUS BEMBUS. PHOTOGRAPH THROUGH THE COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

The carapaces are fused rather roughly in places (see Fig. 9), and a sub-carapace (A) is formed in the tail region, which is overlaid by the usual carapace, much in the fashion of shingles. The plastrons (see Fig. 11) in the head regions are somewhat normal, and the posterior end has a single plastron placed nearly at right angles to the axis of the two heads.

Because of the extremely deteriorated condition of the interior, no effort has been made to get structures other than skeletal, but it seems reasonable to suppose that for the most part each animal has the usual quota of viscera, except possibly in the pelvic region. The presence of two tails might be an evidence that even here the alimentary canal and sex organs may have been separate. These data indicate that this specimen should possibly not be included among the amphicephala.

With the possible exception of the case reported by Townsend there does not seem to be any clear-cut case of amphicephaly in the turtles. Whether Townsend's case is good depends, it would seem, upon the degree to which the structures became common to the two specimens—a point which is not clear either from his photographs or descriptions.

LIZARDS

So far as I have been able to discover, the two lone cases of amphicephalous lizards are presented by Aldrovandi;[17] one of which he reports from another source; the second came under his own observation. Both specimens are here figured.

The first of Aldrovandi's figures is taken from an earlier work by Torquatus Bembus, and represents two lizards with the bodies fused, the heads pointing in opposite directions (see Fig. 12). It does not seem reasonable to call this animal an amphisbaena (or amphicephala) as has been done by Bembus. There is nothing to indicate that these are any more than very simple Siamese twins, fused in an unusual fashion, to be sure, but quite probably without any of the internal organs in common, a thing which would not be so incredible as that shown in his second figure (see Fig. 13), where it seems evident that the two bodies are fused end to end in what should be about the middle region of each animal. In this latter he does not say whether or not an anus is present. The animal was alive when taken, and "walked in the direction of each head."

[17] Ulysis Aldrovandi, "De Quadrupedibus Digitatis Viviparis. Monstra," p. 630. Bononiae, 1637.

After Aldrovandi, 1637.

FIG. 13. AN AMPHICEPHALIC LIZARD

DRAWN FROM LIFE BY ALDROVANDI. PHOTOGRAPH THROUGH THE COURTESY OF THE AMERICAN MUSEUM OF NATURAL HISTORY.

The figure is said to have been drawn from the living specimen.

Since Aldrovandi claims to have seen this specimen while it was living, and also made the figure from the living animal, one can not do otherwise than accept it. This provides, therefore, a good case of amphicephaly among lizards.

POSSIBLE SOURCE OF TRADITIONAL CASES

Since this monstrosity is so uncommon, and since the stories, especially those concerning snakes, are so wide-spread, it is unreasonable to suppose that all the stories of Amphicephala have originated from the actual observation of an amphicephalous type of monster. There are other ways in which this idea may have originated concerning serpents. The credulous may have been fooled by the native Hindu who paints eyes and a mouth on the posterior end of the rubber boa to give it the appearance of being amphicephalic; or by the same treatment accorded the Gila monster by natives. In some cases even artificial decoration is unnecessary, for Ditmars[18] writes as follows:

> The Brown Sand Boa *Eryx johnii* . . . owing to its stubby tail is also called the two headed snake, and, when coiled in a mass with the head hidden and the tail protruding as is a common position, the tail might readily be mistaken for the anterior end.

It also seems quite possible that the idea may have originated from snakes similar to those described by Barbour (*l. c.*). If one, unaware of the habit, should see such an animal crawling with the tail erected, one would immediately conclude the animal was running backward. From that point it is not far to the conclusion that the animal has a head on each end of the body. In animals so spectacularly marked as those shown by Barbour, the deception would be complete.

[18] R. L. Ditmars, "Snakes of the World," p. 35. New York, 1931.

FIG. 14. THE STUMP-TAILED LIZARD (*TRACHYSAURUS ROGOSUS*)

REDRAWN FROM PHOTOGRAPHIC HALF-TONE IN THE BOOK OF POPULAR SCIENCE. BY PERMISSION OF THE PUBLISHER, 1928.

Another source of the idea is made evident by Hawley,[19] who related the following experience:

A few days ago a collection of animals belonging to Mrs. Wombwell made a short stay in this town [Doncaster], and the proprietress circulated handbills describing, among other novelties, a group of *double headed snakes*, a portion of one of which I enclose. Of course, the announcement of so extraordinary an anomaly aroused my curiosity, and I went to see this strange reptile with, to use the words of the keeper in describing it, a head at each extremity of the body, the scales running both ways toward the middle where the vent is situated. I endeavored, but in vain, to obtain a close inspection. The reptiles were kept in a tin box and when exhibited the lid was opened, a quantity of old furs taken out, and one of them was seized by the middle with a long pair of tongs and thus held writhing over the heads of the spectators. The one I saw was just shedding its skin, and parts of the body from which it had separated were dark brown and moist looking. Both extremities were thick and rounded, and from one I distinctly saw a tongue protrude several times; the other was much obscured by fragments of old skin, which the keeper declared, covered another head; but, from the manner in which the reptile was held up, and the respectful distance we were compelled to maintain, it was impossible to determine satisfactorily whether he spoke the truth or not. My own conviction is that the double head is, at most, apparent. If I am right, I think it very proper that such an attempt to impose on the credulity of the public should be exposed; if I am wrong, creatures so extraordinary should certainly not be suffered to remain inmates of a traveling menagerie. I may mention that the keeper related fearful instances of their deadly venom. A young rattlesnake bitten by one of them died in three minutes; a sparrow was swelled in a short time by the poison to the size of a pigeon.

[19] J. R. Hawley, "Snakes with Two Heads." *The Zoologist*, 11: 4153. 1853.

More likely, however, the early ideas originated from a group of legless lizards which, in modern times, have received the name of *Amphisbaena*. These animals, although lizards, appear as snakes because of their legless condition. The bodies are nearly the same diameter throughout, and it is with difficulty that one is able to determine the anterior and posterior ends. Add to this the fact that the animal moves with facility forward or backward, and you have the foundation for the story. The French aptly call these animals "double-marchers." See Fig. 2.

Except for the fact that Aldrovandi specifically states that he observed the lizard specimen, his figure might well have originated from a more or less careless observation of some such animal as the stump-tailed lizards, which appears depicted in Fig. 14, redrawn from an original photograph of the animal published in the "Book of Popular Science."[20] This particular form is a native of Australia.

It is evident that many of the reported cases are based upon hearsay, and that others may be based upon misinterpretation, but, nevertheless, that there are a few cases in which the actuality of existence can not well be doubted must be conceded. It is reasonable, therefore, to conclude that amphicephaly does occur in reptiles, but that it is exceedingly rare.

[20] Book of Popular Science. Vol. xii, p. 4062. By permission. Grolier Soc. (N. Y.) 1928.

MOSQUITO CONTROL ON HYDRO-ELECTRIC PROJECTS

By EDGAR E. FOSTER

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WHEN you turn on your electric lights at home, it may seem that your act has nothing in common with malaria. Yet, in the Southern states, a connection exists, for if you live closely enough to the source you may get both from the same reservoir, unless the power company has taken adequate means to suppress your buzzing nocturnal visitors. If your residence is within flight range of these mosquitoes singing about your head, they may have been hatched in the reservoir created by the dam at which your electricity was generated. However, it is more probable that the engineers of the power company and the public health commissioners have foreseen this problem and have taken adequate steps to prevent the maturing of any dangerous numbers of mosquitoes.

In the creating of any artificial lake as a reservoir for a hydroelectric project, it is always desirable to clear the area to be flooded of all trees and brush which may project above the water surface. However, in the southern parts of the United States and in other parts of the world having tropical and warm temperate climates, such clearing is more than desirable; it is virtually a necessity on account of the sanitary considerations involved. It is always desirable from an esthetic view-point to clear such reservoirs completely; and usually there is some merchantable timber which should be removed for economic reasons. In any case clearing greatly improves

PART OF A RESERVOIR IN A CYPRESS SWAMP

BRUSH AND SMALL TREES HAVE BEEN CUT OUT TO PERMIT EASY DUSTING. WATER IS AT NORMAL ELEVATION.

A RESERVOIR IN A CYPRESS SWAMP

THE BACKGROUND SHOWS TREES, BRUSH AND UNDERGROWTH IN THE NATURAL STATE.

the reservoirs for recreational purposes, such as fishing and boating. However, it is doubtful if all these reasons would justify the cost if it were not necessary for protection of health of the community.

There are a number of serious diseases which are known to be disseminated by various species of mosquitoes. The best known is probably yellow fever; which is spread by the mosquito now called *Aedes calopus*. Although this mosquito is still common in this country, the disease has been stamped out and no longer forms a problem for sanitary engineers. Dengue and filariasis are mosquito-borne diseases that are more commonly found in the tropics and sub-tropics than in the United States, although some cases are occasionally reported here. These two diseases are believed to be conveyed by the mosquito, *Culex fastigans*, with perhaps some other species assisting in the spread of filariasis. However, the *Culex fastigans* and the *Aedes calopus* are domestic mosquitoes—that is, they breed close to human habitation and hence are not a part of the problem of sanitary control on hydroelectric projects. Just the reverse is true of the mosquitoes of the genus Anopheles, which transmits the wide-spread and serious disease, malaria. This genus of mosquitoes necessitates the expenditure of much effort and money to make possible the large hydroelectric projects in the South without impairing the health of the inhabitants of the adjacent regions.

Health is the most urgent reason for clearing reservoirs in all southern parts of the United States on account of the presence of malaria in the human population and the existence of the malaria-carrying mosquito. In this section there is no other disease that may be spread by the creation of artificial lakes or ponds, so that the health problem connected with such waters is reduced to the prevention of this disease.

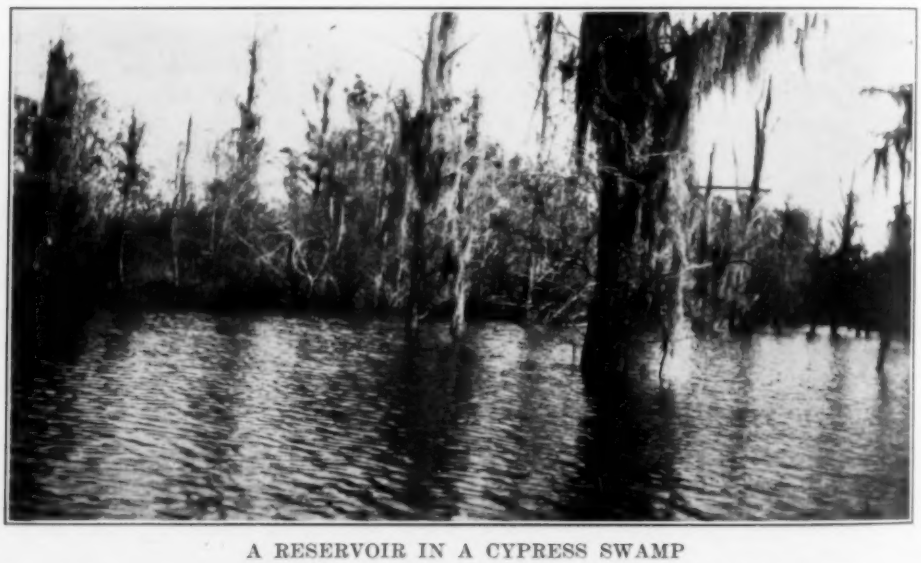
It is now well established that malaria is transmitted from an infected person to a healthy one by the species of one genus of mosquitoes, that is, the Anopheles. In the southern part of the United States, it is mainly the *Anopheles quadrimaculatus*. There are two other species of lesser sanitary importance in the same region, *Anopheles punctipennis* and *Anopheles crucians*.

West of the Rocky Mountains, malaria is spread by still another species and in other parts of the world still other species, all of the same genus, are the carriers. In the south Atlantic and east Gulf tiers of states, however, the *Anopheles quadrimaculatus* is the worst offender, and it is against this species that the efforts of control have been directed on those lakes under the writer's observation.

The Anopheles are a swamp-breeding mosquito, preferring fresh, clean, still water in protected habitats. Suitable protection may be furnished by grass or other hydrophytic vegetation, floating twigs, chips and detritus from decaying timber. They are night flyers, that is, most of their flying is done late in the evening or after dark. During the day they hide in dark corners of buildings, or any sheltered place away from light, and emerge at night. Their maximum range of flight is usually not over one mile, although on their first trip they may go farther, but on that trip they are not infected and hence can not carry malaria. All these facts are important, and on them are based various means of combatting the Anopheles.

The female Anopheles lays her eggs in still pools of water where the eggs and larvae will find protection from their natural enemies. She prefers clear fresh water and rarely deposits eggs in that which is brackish or foul and selects places in swamps or pools where the water is still or moving very slowly. The need for protection is satisfied by grass or other hydrophytic plants, or by floating debris, especially fine stuff which will enable the larvae to hide from small fish and other enemies. The larvae feed largely upon minute forms of green algae which grow most abundantly in the same vegetation and debris that furnishes their protection. These larvae are usually found at or near the surface of the water and floating in a horizontal position; they often appear to be on the surface.

The natural enemies of the Anopheles which are most effective in reducing the numbers of mosquitoes and hence most useful in control work are species of small top-feeding fish or minnows which



A RESERVOIR IN A CYPRESS SWAMP

THE UNDERGROWTH IS CLEARED OUT ON THE EXTREME RIGHT BUT NOT IN THE CENTER.

THE UNDERGROWTH

IN THIS CYPRESS SWAMP RESERVOIR HAS BEEN CLEARED OUT TO PERMIT ACCESS BY BOAT FOR DUSTING WITH PARIS GREEN.

prey upon the larvae. The best known species in the South is the *Gambusia affinis*. Another important fish is the killifish (Fundulus) whose habitat ranges farther north than the Gambusia but has not been used under the writer's observation for control of mosquitoes on hydroelectric reservoirs as the Gambusia has been. The *Gambusia affinis* is a small minnow ranging in size from about one to two inches in length. It is found in fresh or brackish water and will live in foul water. It is a surface feeding minnow, which fact gives it its great value in destroying mosquitoes, especially the Anopheles. Being small it can swim freely among the larger plants and trees and large debris and logs, but small plants, as grass, rice, and pond lilies, will obstruct its movements and prevent it from finding its prey, such as the larvae of the mosquitoes.

In the usual form of warfare against the mosquito, drainage of all possible ponds, pools and swamps near human habitation is the regular procedure. This eliminates the malaria-carrying mosquito, as well as all others, at once by the destruction of its breeding places. However, in the construction of hydroelectric projects that method is out of consideration, for indeed the opposite course is followed in that the land is flooded instead of drained. Other means of carrying on the fight must therefore be sought and used.

Now in the southern part of the United States and other regions where malaria is prevalent, proper preparation of the area of artificial lakes and ponds, such as reservoirs for hydroelectric projects, for flooding must be made as the first step, or mosquito control will be very costly or even impossible. The area to be prepared varies with every project and is dependent upon the topography of the land. In a mountainous or hilly country where steep slopes are the rule, this preparation is relatively small for the reason that the head (or fall) is high, while the amount of power is large and the area to be flooded is small. In other regions, such

A BAY IN A WELL-CLEARED RESERVOIR

FLOATAGE IS ALWAYS LIKELY TO COLLECT IN SUCH BAYS AND NECESSITATES TREATMENT.

as the lower parts of the Coastal Plain, the slopes, especially on the river bottoms, are flat, and a dam with a small head will form a comparatively large lake. One project recently completed has a normal head of 34 feet and floods approximately 11,500 acres of land. In a project of this sort, the preparation of the reservoir may easily cost half as much as the dam, power plant and land and constitutes a controlling item of the total expenditure for the project.

The most satisfactory means of preparing the area of a reservoir for flooding is clearing it of all trees and brush. For all practical purposes this means clearing so that none will be visible above the water surface when it is at the lowest elevation to which it will or may be drawn for any operating purpose. Complete clearing necessitates cutting all trees and brush, leaving as short a stump as practicable, drying and burning or otherwise removing from the area to be cleared. It has not been found necessary to remove stumps, the extraction or grubbing of which would make the cost of nearly any hydroelectric project prohibitive. On low head projects, where the water in the reservoir is shallow, this condition means clearing the entire area; on projects with higher heads, the same results are obtained by clearing completely the area

A CLEARED RESERVOIR

WITH GRASSY EDGES WHICH REQUIRE REGULAR DUSTING OR OILING.

on which the ground will be exposed and on the areas under the deeper water, cutting the trees and brush and tying them down by wire to the stumps, so that they will be completely and permanently submerged. This may be done at a considerable saving in cost.

The clearing of a reservoir is essentially a lumberman's job, although there are several features that are added to the task of cutting marketable timber. All small trees and brush must be cut and all material which can not be economically transported out of the basin (and this includes a very large portion of all that is cut) must be piled and burned. This is accomplished either by cutting up large pieces so that all can be handled by manual labor or by piling it with skidding machinery. For the latter purpose tall trees are left standing here and there by the cutting crews to serve as masts to which cables run from the skidders and thence to the fallen timber scattered over the basin and drag this material into a large pile surrounding the tree mast. After drying, the pile may be burned.

Complete clearing in this manner will leave the reservoir in a very satisfactory condition for all purposes, including recreation and the later operations for control of mosquitoes. Although there will always be more or less floatage of debris from the clearing operations when the reservoir is first filled, this soon disappears and leaves a clean lake in which there will be ample wave action and a clean shore line, both of which are detrimental to the breeding of mosquitoes.

In some cases, however, the problem of clearing is not so simple. In flat regions, where only low head dams are possible, a small drop in the elevation of the surface of the water will uncover a comparatively large area of ground in the upstream parts of the reservoir. While this will be beneficial as long as the edge is clean and free from vegetation, if the water remains down for any great length, the exposed land will soon be covered by weeds, brush, willows and plants fond of wet soils. When the water rises again this growth forms an ideal habitat for mosquito larvae; the wave action is broken up; there is ample food available; and there is good protection from their natural enemies, such as the Gambusia. This alternate exposure and submergence may be caused by the drawing down of the reservoir for water to operate the power plant during a dry summer or may be caused by periodic floods or by both. Of course, lands which are submerged for periods shorter than necessary for the incubation of the eggs and growth

A CLEAN SHORE-LINE

OF A WELL-CLEARED RESERVOIR REQUIRES NO DUSTING OR OILING.

MODERN MACHINERY USED IN CLEARING OPERATIONS

THIS IS A REHAUL SKIDDER USED TO PILE LOGS FOR DRYING AND BURNING.

of the larvae form no part of the problem because there can be no successful breeding of mosquitoes on such land.

In such areas complete clearing is not desirable. Better results will be obtained by clearing only the underbrush and small trees, leaving the large trees to shade the ground and prevent the second growth of brush and other small vegetation. This course will permit the use of boats for chemical mosquito control when the area is submerged and allow free access to all isolated pools by men on foot when the water is drawn down.

In addition to clearing the area to be flooded, other schemes have been prescribed at different times for various projects. In one case, the builders were required to kill all pine trees for a distance of fifty feet from the shore-line of the reservoir. This scheme was abandoned and never put into operation. In several other cases, the project builders were required to clear above the contour of the highest elevation of the water surface for a horizontal distance of fifteen feet beyond the edge of the pond. Neither of these schemes have any effect on the mosquito problem, except that fallen leaves and pine needles may be assumed to float on the surface and form

A FAIRLY WELL-CLEARED RESERVOIR SITE

WHICH HAS BEEN PARTLY FLOODED. SOME LOGS AND LARGE FLOATAGE HAVE BEEN LEFT, BUT THESE WILL FORM NO PROTECTION FOR MOSQUITO LARVAE.

protection for the larvae; but since leaves do not fall until the season for mosquito breeding has practically ended, these schemes necessitate needless labor and cost.

After the reservoir area is cleared and the reservoir filled, continual work of mosquito control must be carried on. Cleared lakes with clean edges or shorelines greatly reduce the amount of work and cost of this control, but nevertheless some is always necessary.

Although they can not be relied upon for complete control, the top-feeding minnow, *Gambusia affinis*, is useful as an auxiliary, and they were planted in one large reservoir for that purpose. However, they are more useful in smaller ponds than usually formed by hydroelectric projects. Yet there is one such reservoir to the writer's knowledge in which the Gambusia play an important part in destroying the mosquito larvae. The reservoir of this particular project contains considerable debris of large size, trees and logs which should have been removed before filling; it is possible that this debris protects the Gambusia, which are very numerous, from larger fish which prey upon them.

For complete control—by which is meant maximum possible prevention—of mosquito breeding, dependence is placed on oil and chemicals.

The oil used in this work is a petroleum product and is usually some oil heavier than kerosene and may be a light crude oil. However, in one case it is claimed that kerosene is better on account of a supposed toxic effect on the mosquito larvae. The oil is sprayed over the surface of the water either alone by air pressure or by being mixed in water by pumps which throw a stream of the mixture as far as one hundred feet. The oil spreads over the surface of the reservoir in a thin film which prevents the larvae from breathing. For this purpose the oil should be light enough to spread well, yet heavy enough so that it will not evaporate for several days.

For chemical control, Paris green is dusted over the surface of the water and poisons the larvae of the Anopheles which eat it. The apparatus and methods used for this are similar as for oil, except that the pumps and sprays are replaced by blowers. Before using, the Paris green is mixed with a cheap inert material, such as lime or limerock dust, in order to effect a greater and more uniform spreading of the poison. This method is particularly advantageous over areas that are not well cleared or in shallow water where boats have difficulty in navigating, because even a very light breeze will carry the dust a long distance and it will filter down through rather heavy vegetation to reach the water beneath. The efficacy of this method is due entirely to the toxic action of the Paris green.

Both oil and Paris green are applied to the surface of the reservoir wherever larvae of the Anopheles may be found. The amount of material and labor required are manifestly reduced in proportion to the amount and quality of clearing done. When the flooded area has been properly cleared before the reservoir is filled, spraying is necessary only along the shore or in small bays and bights where wind and wave action will gather small floatage which will form protection for the larvae or at the mouths of creeks, the water of which may bring down larvae from the reaches above. Wherever there is a sufficient depth of water, boats are used to transport both men and material over the reservoir. For ponds and sloughs which can not be reached by boat, the men must go over the land on foot and carry their sprayer or blower and material with them.

Other methods supplementary to the

above have been suggested and in some cases carried out. One of these is the purchasing by the owners of the reservoir of all land within one mile of the shore-line and moving off this land all inhabitants. This procedure attacks the malaria problem from the human side. Since the malaria parasite must pass a phase of its existence in a human being, the removal of all such carriers from the flight radius of the Anopheles prevents the infection of that mosquito, which therefore can not transmit the disease to other human beings. Since the flight range of the Anopheles is only one mile, it is not necessary to remove the inhabitants from land which lies at any greater distance. To supplement this course a proposal has been made in one case to range cattle on land so purchased. The purpose of this is the furnishing of a source of blood for the mosquito within the one-mile limit so that they may not be compelled to fly farther and become carriers by contact with human beings.

Obviously these supplementary methods are limited to sparsely populated regions, where land values are low. However, hydroelectric projects are frequently built in just such regions and any method of reducing the expense of such costly construction without menacing the health of the people should be a general benefit to the patrons of the public utilities. The reservoir would still be suitable for recreational purposes in the daytime, since the Anopheles is a night-time flyer and hence there would be small likelihood of its infecting persons who spend a day fishing or boating. Camps which are occupied during the night should be adequately screened, however.

Assistance in control may also be obtained by fluctuating the pond level through various seasons. By raising them in the winter, the floatage is lifted to elevations and is driven back on a higher shore-line on which it will remain when the pool level is lowered. The same rise of pool level tends to kill off bank vegetation. Therefore, at the beginning of the next breeding season, the pool is lowered to a clean shore-line, free of floatage and vegetation.

Although the preparation of a reservoir for mosquito control is usually reckoned as a minor part of the construction of a hydroelectric project, you can readily see that it is no small job in itself. It requires the skill and labor of both the civil engineer and entomologist, being, in fact, one of the few grounds on which these two meet in a common task to promote and protect the health of those people in the community of the project, while others at distant places may enjoy their electric conveniences.

HOME ECONOMICS RESEARCH BY THE FEDERAL GOVERNMENT

By Dr. LOUISE STANLEY

CHIEF OF THE BUREAU OF HOME ECONOMICS, U. S. DEPARTMENT OF AGRICULTURE

THE scientific aspect of familiar things is rarely obvious to the layman, and nothing is more familiar to all the world than the daily routine of the household. This, no doubt, is largely the reason why household problems were so long neglected as subject-matter for research.

The importance of this field, however, has been forcibly demonstrated in the United States these past three years. Upon most of the 30 million homes, the depression forced some kind of readjustment. It compelled the family in most cases to count not only pennies but values—in food, clothing and household goods of all sorts, in skills and services required to carry on. Food values, especially, most vital in time of stress—who in the average family knows enough about them to cut food costs to the bone, without incurring a hazard to health?

Under pressure of this kind, if never before, the home-maker realizes her dependence upon home economics research. When a family's funds are at rock bottom, what are the best foods to buy? What will give the most for the money—the most in nutritive value? What at the minimum is an adequate food supply for a family of given size and make-up? How to protect the children on a restricted food supply? These questions call for a scientific answer, not somebody's guess or notion, or long-standing preference or habit.

The U. S. Bureau of Home Economics receives a continual stream of requests for advice and assistance with such problems; letters from individual homes, and from relief agencies; from teachers, child welfare societies, public health clinics, community service groups of all kinds. Fortunately, nutritionists have been at work on these problems for years. The bureau itself is a research agency, with its own nutrition laboratory, its own food utilization laboratory, its own specialists who are continually engaged in original research or in compiling information on the composition and uses of food. One of the major efforts of the bureau in the past three years has been to teach the public how to protect itself so far as possible when forced to live on restricted diets. Balanced diets are worked out at different levels of cost. Weekly market lists of the necessaries are set up. Indeed, so practical is this application of science to every-day life that menus and recipes, gauged to the suggested food supply and at lowest cost, are sent out from week to week, in a press release containing information as to the nutritive values of each and all of the common foods.

The home economics research program has developed in the Department of Agriculture from a beginning more than 40 years ago. Congress in 1887 created agricultural experiment stations in connection with land-grant colleges, and provided for study of the "composition and digestibility of the different kinds of food for domestic animals." In 1893 the Secretary of Agriculture recommended that "questions relating to the use of an agricultural product as food for man should also be considered." President Cleveland, in his message to Congress, commented: "When we consider that fully one half of all the money earned by the wage earners of the civ-

ilized world is expended by them for food, the importance and utility of such an investigation is apparent." Congress voted that year $10,000 "for the study of human food and human nutrition," and the important researches of Dr. W. O. Atwater, already begun elsewhere, became the basis for subsequent work of the Department of Agriculture in this field. That work was carried on from 1894 to 1914 in the Office of Experiment Stations, where the program was widened to include investigations of the relative cost as well as the composition and nutritive value of food materials; studies of dietaries, of the digestibility of certain foods and of the principles of human nutrition.

In 1915, following the passage of the Smith-Lever Extension Act, the Office of Experiment Stations was absorbed in a new unit of the Department of Agriculture called the States Relations Service, through which home economics research was continued under authority of Congress "to investigate the relative utility and economy of agricultural products for food, clothing and other uses in the home. . . ." Thus the field was extended to include the consumption value of all the agricultural products used in the material equipment of the home. Obviously important here, in addition to food products, are cotton and wool.

The Bureau of Home Economics was established in the Department of Agriculture in 1923. This action came as part of a plan by the then Secretary Henry C. Wallace to strengthen the scientific work of the department in respect to home economics. It coincided also with a general reorganization of the whole department on functional lines which separated regulatory, research, and extension work. Thus the field of home economics research was again broadened and this time dignified by the status of a bureau. In addition to studies in foods and nutrition, and the utilization of agricultural products for food, clothing and household furnishings, the bureau now studies economic problems of the home, standards and costs of living, time and energy required for household operations, and trends of household consumption of agricultural products.

Much of the bureau's work in these varied fields is carried on in cooperation with other branches of the department and with state organizations. At present, for example, vitamin studies are under way as a part of poultry-feeding experiments at the experimental farm operated by the Bureau of Animal Industry at Beltsville, Md. Vitamin D, essential to prevention of rickets in children, but not widely distributed in the common foods, is present in the yolks of eggs. Investigators had found, also, that the vitamin D content of egg yolks is greater if the hens are fed on a diet including either cod-liver oil or viosterol, or if the hens are irradiated. Tests have recently been made in the bureau's nutrition laboratory to discover which of these methods of treatment is most effective. These tests show that when cod-liver oil is fed at the usual level, its vitamin D is more efficiently stored in the egg yolk than is the vitamin D of an equivalent amount of viosterol. They show also that 2 per cent. of cod-liver oil is more effective than 1 per cent., but that no greater storage of vitamin D is effected at a 4 per cent. and 6 per cent. level. Fifteen minutes irradiation of the hen with a carbon arc lamp apparently has the same effect on vitamin D storage as 1 per cent. cod-liver oil in the diet. As to viosterol, in these experiments the anti-rachitic value of egg yolk seemed to vary almost as the concentration of viosterol in the diet of the hen.

Another vitamin study now in progress is part of a plant-breeding experiment looking to the production of a variety of potato rich in vitamin A. A yellow-fleshed South American potato,

which does contain vitamin A, is crossed with the common white potato. The breeding experiments are carried on by the Bureau of Plant Industry, and the Bureau of Home Economics makes the vitamin assays of the product. The hope is that a yellow-white potato can be obtained which will contain vitamin A.

Again, potatoes of given varieties, grown under controlled conditions, are tested to determine the effects of different production factors on the cooking quality and palatability. This work, also, is done in cooperation with the Bureau of Plant Industry. Experiments with rice have shown that different varieties require different cooking periods, and that this is true also of newly harvested rice as compared with rice that has been stored for a year or more. Therefore the bureau has suggested to the trade that rice of different varieties or of different ages be sold separately, not mixed. A special study of vegetable cookery is under way to determine methods of preparation that will maintain the vitamin and mineral content of the vegetables, as well as develop and retain the flavor.

Meat studies are in progress to determine the influence of such production factors as breed, sex, feed and age of the animal, on the edible quality of the meat, and to establish a scientific basis for meat cookery. These experiments are carried on in cooperation with the Bureau of Animal Industry and state experiment stations. A satisfactory home method of canning meats and chicken would help the farm housewife to have a better balanced food supply the year around. To develop such a method is the object of other experiments in the food utilization laboratory of the Bureau of Home Economics that tax the knowledge of food specialists, physicists and bacteriologists.

The comparative qualities of different commercial fats are being studied in a series of tests for flavor, creaming power and desirability for deep-fat frying. Included in the study are lards of different melting-points derived from experimental animals produced by the Bureau of Animal Industry. Under a similar plan of inter-bureau cooperation, the effect of a hen's diet upon the physical and chemical properties desirable in eggs for use as a leavening agent are being studied.

In the field of household textiles, the bureau is engaged in the first effort so far made to relate fiber production researches to household utilization. Cotton and wool, as the major subjects of these studies, are manufactured into fabrics under controlled conditions and subjected to wear, laundering and laboratory tests. The relative value of different varieties and grades of fiber for different types of fabrics is thus determined in terms of actual performance.

The durability of cotton materials is affected by the methods used in care and laundering. Studies are therefore being made of the reaction of different varieties and grades of cotton to the temperatures and reagents used in laundering.

Experiments to develop improved methods of finishing cotton fabrics, both in the mill and in laundering, are also carried on in the bureau's textile laboratories. The penetrating and coating power of different sizing mixtures and the effect of these properties on the appearance and usefulness of the fabric are subjects of investigation. These findings will assist the textile manufacturer as well as the housewife to select the suitable finish for a given fabric.

Another part of the textile work combines the development of new fabrics for specific consumer needs with a study of designs for household textiles and garments. New fabrics for special household uses are developed through experimental study and new designs are worked out for household articles which make an effective use of cotton and wool. The bureau was the first agency

in this country to initiate research on clothing designs for children, taking into account health and training of the child. To date, 29 of these designs have been adopted and put on the market by eight commercial pattern manufacturers. Exhibits of the garment models are in constant demand by public health clinics, medical associations, visiting nurse associations, schools, colleges and other organizations concerned with child welfare.

In addition to studies of individual agricultural products, the bureau considers the consumption habits and needs of the family for goods and services of many kinds. Different groups of the population and of families of different economic status are studied. Some are marginal groups, where the need for improvement in standards of living is especially urgent. The information obtained is used by extension workers and others in helping home-makers to make use of family resources. It contributes also to the knowledge of consumer demand which is needed for better adjustment of production to consumption.

Food consumption studies are an especially important part of these standard-of-living investigations. Dietary records are kept for definite periods at various seasons, covering quantities and costs of the different foods consumed by families, individuals, or institutional groups of various social and economic levels. This information is analyzed to determine the amounts of different types of food consumed, their adequacy from the standpoint of good nutrition, and their economy in the diet. On this basis practical suggestions are made to home-makers as to food selection and purchase. For three years past, special attention has been given to low-cost adequate diets and the problems of relief agencies.

The economic researches of the bureau also include studies of the work now carried on in the home and methods of increasing the efficiency with which it is done. The primary purpose is to aid home-makers to make the best use of their time and energy, and of the money spent for household equipment and for other methods of lightening housework. Such information is especially needed at the present time by farm women, where the necessity for a live-at-home program adds many household tasks to schedules already heavy.

The economic value of the home-maker's time when spent in the various household tasks is judged by comparing the money costs of the homemade and the commercial product. There is, of course, a very wide range in the economic return from the different tasks that can be done in the home, and information from these studies provides home-makers with a scientific basis for the choice of tasks on which to spend their time. These studies of household efficiency are also of value to those interested in the planning and building of rural and city homes, to manufacturers and distributors of household equipment, to bakers, laundry owners and others interested in the extent to which commercial substitutes are replacing home-made products and services.

The fundamental point of view from which all the work of the Bureau of Home Economics is carried on is that of the home-maker, who is usually the purchasing agent of the household. The home is the great consumer market for the chief agricultural product, which is food; for other agricultural products such as cotton and wool; for manufactured products in the form of household equipment and furnishings. Very clearly, then, a Bureau of Home Economics, in the U. S. Department of Agriculture, is a link between producers and consumers in the greatest of all markets. It is in a position to give aid, directly, toward a planned economy where consumers' needs and production programs are coordinated.

THE BACTERIOPHAGE IN INFECTIONS OF BONES AND JOINTS

By Dr. FRED H. ALBEE

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It has been said, and with no exaggeration, that upon the activities of bacteria the very existence of man depends. Without bacteria there could be no living organism in the world. Every animal and plant owes its existence to the fertility of the soil, and this in turn depends upon the activity of microorganisms. This also can be said in reference to the digestion of man, particularly in the lower segment of the bowel. Few people assign to bacteria the important position in the world of living things that they justly occupy, whereas only a few of the bacteria known to-day have developed in such a way that they can live in the human body, and for every one of this kind there are numerous others which are perfectly harmless and in no way regarded as the enemies of man, but must be numbered among his best friends.

It has only been recently realized that of these benign varieties the bacteriophage is probably the most life-saving and influential in the welfare of mankind. It has been described by d'Hérelle as an ultra-microscopic living organism which is parasitic in the pathogenic bacteria and reproduces itself. It is so potent that the principle is often active in a dilution of one in 100 million. Most strains of bacteriophage, however, are specific for certain kinds of bacteria or even for certain strains of these species. The bacteriophage may be present in small quantities in culture but remain unnoticed and may be the cause of variations occurring apparently spontaneously. The nature of the bacteriophage has stimulated a large amount of research on account of its impending importance throughout the realm of medicine and surgery.

In the field of entomology beneficial pests or parasites have been long used with much benefit in the economic life of man in particular relation to domestic animals, crops, etc., in counteracting the activities of injurious species. The benefits derived by man from beneficial organisms are very great, and it is most fortunate that practically every destructive species is preyed upon and kept within bounds by the attacks of other organisms, either parasites or predators. But for these natural controls, man would stand little chance of successfully competing with these hosts of injurious animals. Biological or natural methods of controlling pathogenic organism in the human subject have not been considered possible until this newly observed phenomenon was first described by F. W. Twort (1915) and F. d'Hérelle (1918), who found an ultra-microscopical parasite of pathogenic bacteria which had markedly beneficial effects in certain acute intestinal diseases, such as bacillary dysentery and cholera. This parasite he called the "bacteriophage" because it lived on virulent pathogenic bacteria and destroyed them, thus in many instances saving the patient's life. There were, he demonstrated by laboratory experiment, several varieties or "races" of phage, each with a preference as to the type of bacteria it would destroy; but also having certain adaptable destructive influences toward other strains of bacteria.

In one of his earliest experiments with dysentery bacilli he added about 0.0001 cc of bacterial culture to a young broth culture and subcultured the mixture immediately to an agar slant. Ultimately, the surface of the agar was well covered with a roughened layer of the

multiplying bacteria. Then, after a long period of time, two little islands appeared, two clear plaques perfectly circular in form where the agar was bare, entirely free of all traces of the bacterial colony. D'Hérelle explained this striking phenomenon by the spontaneous appearance of a bacteriophage which absolutely destroyed the bacteria with which it came in contact.

To prove this, his next step was to apply a platinum loop to the roughened surface of the agar and transfer a bit of the bacterial colony to a test-tube of clear bouillon and incubate it. Within a short time, the tube was so teeming with bacteria that it was turbid and opaque. D'Hérelle then transferred to this turbid culture an infinitesimal portion of one of the clear plaques on the agar slant. After a few hours, the bouillon, as if by magic, became perfectly clear and transparent, and centrifuging of the culture failed to disclose any bacteria whatsoever. Not only had all bacteria been killed, but their bodies had been lysed or dissolved.

Now if a chemical germicide had been placed in this tube or heat applied, the bacteria would have been killed, but at the bottom of the tube there would have been a sediment, a deposit as a result of centrifuging, millions of dead bacterial bodies. Not so in this tube of d'Hérelle. There was not a trace of sediment. Not a dead bacterial body could be found.

The analogy between these experiments and the spontaneous appearance in a bone or joint wound of a bacteriophage, when one seals it up for a long period of time (6 or 8 weeks) with such substances as vaseline gauze, Bipp or my paraffin tampon, is striking. Following operation or at subsequent dressings, when one fills the wound with the paraffin tampon it is discharging profusely. When the dressing is removed, at the end of 6 or 8 weeks, there is a marked change. The granulations are red, velvety, and in every respect the wound has the appearance of a healthy one, provided a bacteriophage has appeared spontaneously. It should be noted that the same phenomenon, namely, the spontaneous appearance of a specific phage, has occurred here as in the test-tube observation of d'Hérelle. The important element in the two phenomena, the one in the test-tube and the other in the wound, was a sufficient lapse of time without sweeping away the discharges or products of the wound or without the introduction of extraneous contamination. According to d'Hérelle, certain races of phage were always present in the intestinal tract of man. Their parasitic activities, however, apparently increased in accordance with the number and virulence of pathogenic bacteria with which they came in contact and had a specific action. It was further found possible to increase and intensify this parasitic action by administering doses of a laboratory prepared highly specific phage.

The action here is analogous to that which happens in a citrus grove of Florida, which is infested with an organism known as the purple scale, which kills orange trees just as pathogenic bacteria kill human tissue. There are open to the agriculturists two methods of combatting this destructive organism: (1) to spray his trees with a strong chemical which is somewhat analogous to the Carrel-Dakin treatment of a wound, and the other method is to use a beneficial parasite or, speaking in surgical parlance, a bacteriophage, to destroy the resistant enemy organism. The beneficial parasite commonly used in this instance is known as the red-headed ray fungus. This organism penetrates the body of the adult scale and eventually kills it as well as its eggs or larvae. If the fungus does not spontaneously appear in the grove, which it usually does not, the agriculturist introduces it from the laboratory himself. Relatively small inoculations will suffice in that it proliferates rapidly and spreads throughout the grove. It is a biological agent

and is actively aggressive in its destructive influence upon the enemies of the grove. On the other hand, the chemical spray will have no influence except upon the organisms that it mechanically reaches, or a rain may immediately wash it away, and in this particular scale its potency is very unsatisfactory. Further, it has been found undesirable to spray with chemical a grove in which the beneficial parasite has been introduced or has appeared spontaneously, as the chemical has been found to be more destructive to the beneficial parasite (or bacteriophage) than to the pathogenic organism. A lesson, I believe, should be drawn from this with respect to the surgical use of the bacteriophage in wounds. When one is looking for the beneficial action of the bacteriophage he should never introduce into the wound a bacteriocide in the form of a chemical.

Since time immemorial infected wounds have been the surgeon's *bête noire*. One needs only to read Homer and other ancient writers to realize this, and a review of wound treatment throughout the ages gives renewed evidence of the old adage that doctors differ, and proves again that scientific advances move in cycles. The search for ideal wound treatment is centuries old. Primitive man's wounds were dressed with dry moss or fresh leaves, ashes or natural balsams. The spear and arrow wounds of Homer's heroes were treated by sucking and cauterization with hot irons and filled with pounded root powders. After any of these local measures had been carefully applied, appropriate incantations, recited with religious fervor, were considered necessary to insure healing.

Enough has been stated to show the unusual attitudes taken in reference to wounds throughout the ages, and there has been no more revolutionary departure in this important part of surgical practise than the one I am to set forth in this communication.

The first intimation of abandoning the customary frequent dressing of wounds was a brief description by Gooch of his doctrine of non-interference. If his technique were described in more detail we might find a resemblance to the Bipp or Orr treatments. Hunter, in connection with his classic study of circulation and information, remarked that it was sometimes just as well to let a wound alone. The nineteenth century was outstanding because of the introduction of antiseptics and germicides by Lister.

With the world war came the Carrel-Dakin treatment, the acme of antisepsis. It combined qualities which no previous wound antiseptic had. It did not harm the tissues. It dissolved the wound exudates and thereby permitted the nascent chlorine which it contained to penetrate to the bacteria in the deep recesses of the wound. As compared with previous methods of treatment the results were excellent. There were, however, obvious objections to the treatment, and as the rush of war surgery abated the objections gained more weight. The frequency of irrigation and dressings were distressing to the patient, arduous for the surgeon, and always associated with the risk of reinfection with extraneous organisms. It also necessitated prolonged hospitalization, a serious drawback of any treatment, particularly in these days of depression. The necessity of cutting a window for the insertion of the tubes and the softening of the cast by the constant introduction of the Dakin fluid rendered immobilization imperfect, which is so important in the prevention of oedema in the granulations, deep portions of the wound and the surrounding soft structures. A uniform pressure over the wound, as well as the neighboring structures, is most important. The above enumerated handicaps also applies to the use of the maggots.

My present method of treating osteomyelitis and suppurated joints, both

acute and chronic, is as follows. For purposes of brevity, the surgical technique will not be discussed at this junction. Suffice to say that the indications are the same and the precise operative surgical work is carried out whether the phage is used or not.

Technique: The usual sequestrectomy and saucerization are completed, and a culture is taken. I do not use alcohol or iodin, lest they interfere either with the development of the spontaneous phage or with the specific laboratory-bred phage after its introduction. (If a specific phage has already been found from a culture previously taken from an existing sinus, two thirds of a test-tube of this phage is poured into and over the wound, so that the whole surface is bathed.) The wound is then filled with a paraffin and vaselin mixture, 75 per cent. paraffin to 25 per cent. vaselin, providing the wound is shallow and there is no danger of its orifice at the skin closing too soon; or, in cases where the wound is deep and made through heavy muscles, 90 per cent. paraffin to 10 per cent. vaselin is employed. No vaselin gauze whatsoever is used. The paraffin and vaselin are heated to 110° F. and poured in as a liquid or forced in by pressure through a large syringe. In most cases, the syringe is the method of choice, in order to insure penetration of the mixture to the innermost recesses of the wound. The orifice of the wound is closed over with several layers of gauze saturated with the same paraffin compound and the end of the syringe is inserted through a tiny hole in this saturated gauze and the wound cavity, with all its recesses, completely filled.

A rubber catheter is inserted through the paraffin-vaselin wound tampon to the bottom of the bone cavity. The other is allowed to project through the dressings and cast (which are applied as usual), with a sterile gauze or cotton over the end. If the laboratory examination of the culture reveals that it is possible to develop a bacteriophage specific for the organism presented, ten cubic centimeters of this phage are injected through the rubber catheter once or twice a week. Care should be taken when making periodic injections not to infect or contaminate the end of the tube. Should the bacteriophage appear spontaneously in the wound, injection of the laboratory-bred phage is still of advantage in that it accentuates the action of the native phage and may be a more specific one. This practise is of still further advantage because if an original phage does not completely destroy a culture, the organisms that survive give rise to a resistant strain which may not only be pathogenic for its host but later be unaffected by a more specific bacteriophage. In large wounds, several catheters may be inserted, some of which are multifenestrated. Inasmuch as the catheter is firmly imbedded in the paraffin-vaselin tampon, the injected phage fluid can not flow backward between the catheter and the tampon. It must, therefore, make its way *inward* between the tampon and the wound granulations, and thus, by reason of its own bulk, spread widely. Furthermore, since the phage is, by nature, a multiplying organism, it will thus automatically spread over the wound surface.

At the end of eight weeks the cast is removed and the wound dressed, great care being taken not to traumatize the granulating surfaces. The discharge around the edges of the wound is wiped off very gently with sterile gauze and the skin cleansed with benzine.

If the wound is not entirely healed when the cast is removed, it is again bathed with a test-tube of the prepared specific phage fluid and a catheter or catheters inserted to the depths of the wound. A paraffin-vaselin tampon is used as before and a cast applied for an eight-week period. A culture is also taken at this time to determine whether the bacterial flora of the wound has

changed, and also whether a more specific race of phage can be obtained. Periodic injections through the catheter are given as before.

I have recently completed a statistical study of 100 consecutive cases treated by this method which shows that the average healing time for a case of osteomyelitis so treated is about six months. The type of infecting organism varies—staphylococcus, or a mixed infection with staphylococcus predominating, being the most frequent. It is interesting to note that the bacillus Welchii appeared in seven of the series of 100 cases. However, the rod was extremely weak and attenuated and did not interfere in any way with the healing of the wound. The flora changed in 22 per cent. of the cases, usually to a more favorable type of organism, resulting in rapid healing.

Those cases in which a native phage develops usually do very well without the insertion of a laboratory-bred phage. However, in view of our latest investigations, we feel it is wise to inject periodically a race of phage of the highest potency, in order to have at work for a maximum period of time a phage of the highest specificity. In this way, any possible decrease in potency of the native phage is offset.

The treatment of a group of cases of osteomyelitis with complications, such as infected fractures and joints, entails a multitude of considerations. In most of these cases, we have deep wounds extending into the bone, with varying degrees of infection. The ideal wound dressing must, therefore, have a degree of solidity sufficient to restrict the tendency of the orifice at the dermis to close earlier than the depths of the wound. At the same time, this tampon should be such that it can be inserted in practically a fluid state, in order to flow uninterruptedly to every recess of the wound; it should then become semisolid, thus tending to conserve the original contour of the wound, avoid adherence to the bone, and, bit by bit, extrude automatically as granulations fill up the depths of the wound, or as the contractions of healing and cicatrization demand. The paraffin tampon measures up to these requirements very well.

I do not favor the vaselin, vaselin-gauze dressing for several reasons:

(*a*) It is impossible to satisfactorily control the consistency of the vaselin, vaselin-gauze tampon. Due to the ingredients comprising it, this tampon can not, at best, be uniform in its consistency or tend to hold its original conformation.

(*b*) Later experience has shown that, even when an excess of vaselin is added with the vaselin gauze, the gauze is still apt to become adherent to the bone at the bottom of the wound and so resist extrusion of the tampon and delay healing.

(*c*) The wound granulations are likely to strangulate through the meshes of the gauze.

None of these complications ever arises with the paraffin and vaselin dressing, which, because of its proper degree of solidity for the particular case, the uniformity of its consistency and its slippery surface, will always extrude much more satisfactorily than the vaselin, vaselin-gauze dressing. Furthermore, it has been found that the bacteriophage occurs spontaneously just as frequently as with the vaselin-gauze dressing; also, the laboratory-bred phage, when introduced, acts as favorably. I have been unable to find any shortcomings of this dressing as compared with either the Bipp or the vaselin, vaselin-gauze dressing. Bipp, however, may be contra-indicated because of the possible unfavorable chemical action of the iodoform upon the bacteriophage.

In addition to its application to infected bone wounds, the bacteriophage has proved a most efficacious specific agent in combating lesions such as fu-

runcles, boils, carbuncles and phlegmons. For these conditions it may be applied in two ways:

(1) It may be thoroughly rubbed over the surface of the wound and the lesion covered by sterile pads soaked in bacteriophage; or, if the lesion is of extensive size or depth, it may be dressed with the paraffin and vaselin tampon with a catheter incorporated for periodic introduction of bacteriophage.

(2) It may be injected subcutaneously into the soft parts by means of a hypodermic needle about the periphery of the lesion.

In *bacteriemia*, particularly with staphylococcus aureus, a bacteriophage, prepared with asparagin as a medium and injected into the blood stream, has, in the hands of Dr. MacNeal,[1] reduced the mortality from practically 100 per cent. to less than 50 per cent., even when there have been two positive blood cultures. Not only is the bacteriophage a successful local therapeutic agent, but it has the added advantage of helping to establish a possible general so-called immunity on the part of the patient. Also the bacteriophage is, to some degree, effective in experimental animals when injected at a site distant from the infected focus.

The invariable excellence of the results of this new method of treatment for infected wounds should make it unquestionably preferred by all those who experience its advantages over former methods. I believe that the bacteriophage will eventually become one of the surgeon's important weapons against infection. Its potency has become so widely recognized that certain governments (India and Brazil) have passed laws that it be kept constantly on hand for use in certain intestinal diseases. My desire is to stimulate the interest of the surgical world in a phase of bacteriology which will have a profound influence on the future treatment of surgical infections.

My experience with this new method for treating osteomyelitis has convinced me that it is far superior to any other method I have used, and this conviction is borne out by the statistical study which shows the time of healing materially reduced. A summary of the advantages of the dressing follows:

(1) It is simple in its application, requiring a minimum amount of labor on the part of the surgeon and his staff.

(2) It does not interfere with the immobilization of the part (as, for example, in the case of a compound infected fracture or suppurating joint), nor does it favor oedema of the granulations or the soft structures because of inequality of pressure at or in the immediate neighborhood of the wound, since there is no window in the cast. This is quite contrary to the Carrel-Dakin or maggot method of treatment, both of which must, of necessity, have a window in the cast. I believe that a uniform pressure over the wound and neighboring tissues (such as this method affords) will avoid oedema—an important consideration in the healing of a wound, as is exemplified in the case of varicose ulcers.

(3) The paraffin-vaselin tampon automatically yields to the encroachment of granulation, healing and closure of the wound, thus gradually extruding and keeping up a constant physiological pressure upon the surface of the wound at all times. This is more effective than frequent dressings by the surgeon, and, in addition, avoids the possibility of reinfecting the wound by a foreign flora of bacteria.

(4) This dressing is favorable to the appearance of a native bacteriophage and to the periodic introduction of a laboratory-bred phage.

(5) It requires a very short period of hospitalization, which at this time of depression is one of its most important advantages.

[1] New York Post-Graduate Hospital.

SCIENCE SERVICE RADIO TALKS

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CHEMISTRY AND DAILY LIFE

By Dr. CHARLES M. A. STINE

VICE-PRESIDENT, E. I. DU PONT DE NEMOURS AND COMPANY

ONLY a few generations ago, manufacturing consisted almost wholly of changing the form of raw materials found in nature. In some measure, this is the case to-day and is likely to continue indefinitely. For instance, trees are felled and sawed into lumber of various shapes. In turn, the lumber is worked by machinery or by hand in the making of, say, furniture. Again, the fleecy content of the cotton boll is spun into yarn and the yarn woven into fabric. True, the surface of fabricated wood may be modified in appearance or disguised by the application of lacquer, varnish, paint or some other finish, while cotton yarn may be bleached or dyed, or the cotton textile may be bleached, dyed or printed. However, a wooden article, produced by merely changing the form of the raw material, is still wood, while raw cotton, though changed as to its form, remains cotton.

Facilities for making things of wood, cotton and other natural materials long ago passed through a transition from the use of hand tools—the spinning-wheel, hand looms and other manually-operated equipment—to power-operated machinery and looms and the like. Thus it was that we entered the Machine Age. But manufacturing was almost wholly concerned with altering only the shape of natural materials.

During the past quarter of a century, and more particularly during the less than two decades since fateful 1914, with the start of the world war, there has grown up in the United States a tremendously important new industry, described broadly as the diversified industrial chemical industry. Therefore, some who like to coin new words and phrases are wont to style the time in which we now are living the Chemical Age.

In these modern days, the industrial chemist, along with the designers of wood-working machinery and textile machinery, is interested in wood and cotton, but the chemist's interest in such basic raw materials is for an entirely different reason. The chemist is not concerned at all about simply changing the forms of wood and cotton. What he sees in these two materials are sources of cellulose. He takes wood, if it be of the kind rich in cellulose content, and makes from it rayon and certain other products of a considerable group. Of cotton, the industrial chemist makes a very much wider and more diversified range of products, largely because cotton is almost pure cellulose. In either the case of wood or of cotton, the finished products are in no respect similar to the raw material in appearance or physical or other properties.

Although cotton in the form of fabric is not the form most widely used by the industrial chemist, it is entirely possible to take a cotton dress or a cotton shirt and by chemical processes make rayon, motion-picture film, a lacquer for automobile finish, transparent waterproof cement, or any one of many others of the chemical products used daily in the home or elsewhere.

Before the present developments along the lines of industrial chemistry, manufacturing was limited to the use of natural materials. Also, man had to take these substances as nature had produced them for purposes of her own economy. As a result, many of these natural mate-

rials possessed serious undesirable properties, judged from the standpoint of their applicability to industrial and other uses.

Take rubber as an example. Natural rubber, as is well known, is derived from latex, the milky juice of the rubber tree. It is believed that the purpose latex serves is to protect the tree from certain insects. This being the case, with nature not having developed this juice for man's use for such purposes as the making of overshoes, automobile tires and various other rubber products, it is not at all surprising that latex has certain undesirable properties.

An animal's hide or the skin of a reptile is provided by nature with a view not only to meeting the general requirements of species but to suit the peculiar needs of the individual. The texture and the physical properties of any hide or skin may be further modified by the health of the creature, the season of the year and other factors. These considerations make it obvious that there is a marked difference in uniformity; in fact, no two pieces of such natural materials are exactly alike. It is, therefore, very evident that nature is not at all concerned about the use of the external coverings of her creations in the making of handbags, bookbindings, furniture coverings or for any of the other artificial uses to which skins and hides are put.

Similar considerations apply equally to such natural products as ivory, mother-of-pearl, and to the gums and oils used in paints, enamels and other finishes, to mention but a few. Besides, with many materials found in nature, there is the limit of size to further handicap those who would make use of the stuffs. Nor are some of these materials always to be found close at hand; rather it is necessary frequently to go literally to the ends of the earth for certain raw materials, while all too often the available supply is very inadequate.

Again, the multitudinous and special requirements of our complex present-day life make necessary things which were not even dreamed of in the so-called good old days of the horse and buggy, the windjammer and tallow dips. And it is to the chemist's test-tube that we moderns look for new materials and new applications to increase our comfort and enjoyment, our advancement along economic and social lines and even certain phases of political progress.

Since rubber is at once one of the most familiar and most useful of materials, let us consider what the chemist has achieved in making it synthetically. Known as DuPrene, synthetic rubber is now produced from such common materials as coal, limestone, salt and water. These are found right here in our own country, and in the greatest abundance. Therefore, it is no longer necessary to depend upon distant sources of supply of natural rubber, should a situation arise that would make it either necessary or desirable to manufacture rubber to supply all our needs in a factory instead of importing the natural product from distant parts. Not only is DuPrene a satisfactory substitute for natural rubber for almost every purpose, but it is, in fact, superior to natural rubber for certain uses.

Cowhide and snake skins can be so closely simulated in appearance by lacquered fabrics that it is not necessary to depend entirely upon the natural products for materials for use for bookbindings, upholstery, hand luggage and various other purposes. A woven cotton backing with a surface coating of lacquer, derived from nitrating the linters shaved from cottonseed, gives us a waterproof material of fully sufficient strength and great durability. It can be made in any desired width and length, while every square foot can be identical in appearance and quality, owing to chemical control in the manufacturing of this lacquered fabric.

From cotton as a basic raw material, the industrial chemist makes plastics

with the appearance of ivory or mother-of-pearl, and in artistic or other effects of which there are not to be found counterparts in natural substances.

Synthetic gums and oils developed in the research laboratory are now produced in the chemical manufactory for use in the making of interior and exterior finishes of a distinctly different type from enamels made with natural gums or paints using natural oils in their composition. Camphor, which, as a natural product of a tree, comes from Japan and other parts of the Far East, may now be made by chemical processes from one of the constituents of turpentine, while the turpentine is obtained from the pine stumps of our own southern states. Though the extent of the use of camphor in the manufacture of chemical products may be little appreciated, it really amounts to thousands of tons annually.

What are known commercially as naval stores consist of materials from pine stumps and include rosin, turpentine, pine tar and pitch and pine oil. The industrial chemist uses rosin in making sealing wax, electrical insulation, paper, paint, varnish, soap, linoleum, printing ink and for foundry purposes. Turpentine is used by the chemist in medicines, perfumes, paint, varnish, shoe polish and, as has been mentioned, synthetic camphor. Pine tar and pitch find uses as rubber softeners, in paint and on rope or cordage. Pine oil is used by the chemist in disinfectants, for reclaiming rubber, in medicines and perfumes, for mineral separation and in the textile industry. Without the aid of chemistry, the southern pine stump would remain little more than an obstruction on cleared land. Chemistry gives the pine stump an industrial value.

Fixed nitrogen for industrial and agricultural purposes is highly important. Not so very long ago, the chemical manufacturer and the farmer had to depend very largely on natural nitrate of soda imported from distant Chile, though some was obtained by the distillation of coal. Quite a different picture is now presented, with chemistry obtaining a plentiful supply by fixed nitrogen from the air as ammonia.

The scientific research worker and the industrial chemist are giving lively and increasing attention to the American farm as the source of substitutes for a considerable number of basic materials. It is now realized that the millions of tons of agricultural wastes which are produced annually in this country offer a potential source of basic substances for use in industry. Eventually this must increase demand to such an extent that the chemical and other manufactory will consume more of the products of agriculture than does the human stomach. This holds the prospect of greater prosperity for the tiller of the soil.

The importance of the midwestern section of our country from an agricultural standpoint could well operate to make it at some future time a vast industrial locality, because of the availability of farm products for which the scientist will discover manufacturing uses. Such a development finds a striking parallel in the South, which from an almost wholly agricultural territory has also become a highly important industrial one by reason of the fact that the South's cotton crop and certain of her natural resources have supplied materials needed by chemistry for the creation of entirely new industries and the revolutionary development of some old lines of manufacturing.

Throughout the entire country new industries have come into being as a direct result of fundamental chemical research, and the utilization of the results in chemical manufacture. New needs of humanity have, time and again, been supplied by materials developed in the laboratory. The fruits of fundamental research along chemical lines in many cases represent indispensable knowledge of various materials which occur in nature. Continual additions to

this field of knowledge are indispensable to the development of new products and appliances for increasing man's comfort and improving his health and living conditions.

Opportunities for employment also have been vastly expanded as a result of jobs created by new industries established to manufacture products developed by the chemist and his coworkers. As a result of the discoveries and inventions of our scientists, America has come to a state of economic independence which is practically complete along every line. We have fixed nitrogen and we need no longer import nitrates from Chile; we seem to be about to develop our own potash resources in the Southwest; we are able to make, should the occasion arise, synthetic rubber of acceptable quality. These are merely a few striking examples of the tremendously important contributions which our own development of chemical manufacture has made toward American economic independence.

EXPLORING THE ATLANTIC'S GREATEST DEEP

By Dr. PAUL BARTSCH

CURATOR OF MOLLUSKS AND CENOZOIC INVERTEBRATES, U. S. NATIONAL MUSEUM; DIRECTOR, JOHNSON-SMITHSONIAN DEEP-SEA EXPEDITION

THE Johnson-Smithsonian Deep-Sea Expedition to the greatest of the Atlantic's deeps, the Puerto Rican Deep, was made possible through the generosity of Mr. Eldridge R. Johnson, of Philadelphia, the genius who organized the Victor Talking Machine Corporation. Mr. Johnson placed his wonderful yacht, *The Caroline*, at the disposition of the Smithsonian Institution and equipped her without quibble or stint with the most up-to-date instruments for marine exploration. Through the cooperation of all agencies at home and many abroad, we supplied the ship with all the necessary gear to enable us to achieve what I may now claim, without egotism, to be a greater return than that obtained by any previous expedition in an equivalent period of time. This material is now in the hands of specialists for report. You will also be pleased to hear that we are busily at work with the creation of a new winch that will enable us to obtain specimens from any depth, next year, when we return for a final effort to the Puerto Rican Deep.

To-day I thought you might like to hear something of our biological catches. As all living creatures of complex organization begin as a single cell, I may be pardoned by beginning with the unicellular creatures, secured with our Nansen water bottle and our finer tow nets and bottom samples. Most of these —whether plants, such as diatoms and algae, Foraminifera (the chalk animalculae) or Radiolaria (dwellers in glass houses)—are so exquisitely sculptured and ornamented that the term "beautiful" appears hackneyed and trite when applied to them. These minute plants and animals occur in such vast numbers, sometimes several millions in a single quart of water, that we should really look upon the sea not merely as a watery waste, but as a richly stocked aquarium.

This teeming minute life is particularly abundant in the upper stratum of the sea, where the penetration of sunlight makes possible the photosynthetic action of the chlorophyl organs of the tiny plants. We may therefore agree with the author who first called the upper hundred fathoms of the sea "the grazing ground of the oceans." It is this rapidly multiplying microscopic life that furnishes the food supply to the larger small creatures, which in turn feed larger forms, even the huge whales,

and, finally, the king of all animals, man. Nor do they serve as food alone, for the Foraminifera, when they shuffle off this mortal coil, sink slowly to the ocean floor, where they form an ooze which in time may consolidate into rock, as evidenced by the chalk cliffs of England that caused Caesar when he first saw them to give the name Albion to the land.

So the geologist, seeking the earth crust's treasures, drills into the ground, and an examination of the core which he brings up, for Foraminifera and mollusk shells, will help him know the stratum to which his drill has penetrated; they are his finding and directing marks. The Radiolaria, on the other hand, gives us Barbados earth, and Tripoli your polishing pastes and powders.

The next higher group, the sponges, were well represented in our catch, ranging from the toilet sponge group to the beautiful glass sponges, of which we obtained three species. When it comes to the Coelenterates, I might devote an hour to the discussion of the coral reef without wearying you, I am sure. Of flat and round worms Dr. Price obtained no end of new species and higher groups parasitic upon deep-sea fishes, which had never been explored for such companions. The Bryozoa and Brachiopods yielded their share.

The Echinoderms furnished many curious serpent or brittle stars, sometimes more than a gallon full in a single haul; also sea stars, sea eggs, curious brilliantly colored Holothurians, and sea lilies, both sessile and stalked. The latter furnished a new experience for me and rendered me almost as excited as the novices on the cruise. Of the stalked sea lilies we secured no less than two dozen in a single haul.

Worms were caught a-plenty, and Crustaceans were abundantly represented in our catch. Were I to stop and discuss my pets, the mollusks, I would need at least a day to give you an adequate account of what we obtained. Suffice it here to say that we added many new species and quite a number of new genera.

Experiments have shown that highly sensitized photographic plates, exposed below 10,000 meters even for a protracted period, show no effect, and these observations have caused the general belief that animals living below this depth exist in everlasting darkness. I am not altogether convinced about this. Most of the deep-sea fishes have splendidly developed eyes—usually larger than those of species living in shallower water. Of what use would these be if Stygian darkness prevailed? Most marine creatures are phosphorescent and many of them, if not all, are more or less fluorescent; that is, they are made to glow when actuated by ultra-violet rays.

Many of the deep-sea fish are provided with highly developed phosphorescent organs and baits that they may make glow. Or some, like the hatchet fishes, when seen alive appear as if the dark parts were cut out of jet and the light areas covered with translucent celluloid and the interior provided with a toy lamp. Where you have enormous numbers of the tiny unicellular organisms, like the Peridinia, present, as I once observed in Manila Bay, they emit enough light when agitated by a passing launch to enable the occupants thereof to read a paper by their glow.

All these things make me wonder if after all there may not be a glow, like that in our atmosphere on brilliant starlit nights, present in the deeps with an occasional meteoric flash produced by the glowing bait or phosphorescent organs of some larger denizens of the deep. It also seems quite possible to me that some of these flashes may awaken and set aglow fluorescently the lesser folk when thus eradiated. A reaction of this kind offers an explanation for the marvelous development of the light-emitting organs covering the belly of the lantern fishes or the sides of many others. In my mind's eye I see the deep rendered faintly aglow

by its myriads of tiny folks, and in the glow I see momentary searchlight flashes produced by larger creatures which not only set into relief the other things but cause them to flash with a sympathetic fluorescent glow.

Probably you would like to visualize some of these denizens of the deep. Were television as widely used as the radio is to-day I should take delight in projecting pictures of some of the creatures obtained. As it is, I shall attempt to briefly describe two or three of the deep-sea fishes we caught:

The Viper Fish, Idiacanthus

Conceive a slender, very long, eel-like purplish black body tapering from the neck to the tip of the tail, which equals about one fourth the diameter of the neck, made up of 90 miomeres or segments which are laterally compressed. The 4th to 12th of these segments bear a phosphorescent organ on their dorsal half, while the 3d to 28th have in addition two of these glowing structures on the ventral half, and on the 29th to 90th a single lamp is present. This count is repeated on the other side. We have thus no less than 248 tiny lamps on the body of this creature. Nor is that all, for there are two glowing spots on each cheek behind the eye. There are also 6 such organs on the throat, raising the total to 256, and then, most marvelous of all, there is a long filament—a chin whisker springing from the under side of the front end of the throat—which bears a bifurcated glowing torch-like tip, twenty-five or more times the size of the other structures, that can be waved in front of the fish's mouth to invite prey to come within the most exquisitely fang-toothed jaws that you can imagine.

The Lantern Fish, Neoscopelus

Shaped like a trout, brownish red above the darker mottlings, greenish spotted about the head, provided with 118 large phosphorescent organs on the belly and a huge one under the chin. The position of these lamps on the under side of the fish certainly suggests lighting things up below as he swims about.

The Eater of Stars, Astronesthes

Cod-shaped, pitch brown and black with a row of 46 phosphorescent organs stretching along its side a little above the ventral margin and another of 72 a little below this, that is, 118 on each side, or a total of 236 lamps. This fish, too, has a long chin whisker with a lovely glowing bulb at its tip, which it is able to swing and wave in front of its very large fiercely toothed mouth.

NERVE MESSAGES

By Dr. D. W. BRONK
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If, while walking barefooted, you suddenly step on a sharp object your foot is quickly withdrawn. That simple act depends upon a remarkable communicating system which keeps the various parts of your body working together as a smoothly running machine. Some such system is necessary, for we are built of countless cells or units which must be regulated and controlled if they are to function as coordinated members of the living organism. This control is carried out primarily by the nervous system. The brain and spinal cord dominate and dictate the activities of the other parts of the body, and they do this by means of messages traveling over the nerves that connect them with these other parts.

In order that a business executive may efficiently govern the activities of a large number of individual employees it is necessary that he know business conditions in the community in which his

company operates, and that he also be kept informed as to the state of the various departments of his own organization. And so it is in the case of the complex living organism. There are on the surface observation outposts, or sense organs, such as the eye for light, the ear for sound, and others for touch, temperature or pain, which keep the controlling and coordinating center, which is the brain, informed about our surroundings. Similarly, there are in the muscles sensory structures which are stimulated by a contraction of the muscle, and others in the walls of arteries which respond to a change in blood pressure. From these various sense organs there go slender strands of living matter known as nerve fibers; hundreds or thousands of these fibers being bound together into nerve trunks. Over these nerves travel the messages which inform the brain about our physical environment or about the conditions within our own body. The first question I wish to consider is the nature of these sensory nerve messages.

We have long known that the main function of a nerve is to conduct very brief pulses or waves of electrical and chemical change at speeds which range from one to several hundred feet a second. If, therefore, we connect a nerve to an electrical recorder we should be able, by making use of these electrical changes that constitute or at least accompany the nerve impulses, to photograph or hear the messages which come over the nerve. In doing this it would be desirable to record what passes over just one nerve fiber, in order that the message be not confused by simultaneous messages of a very different sort traveling over hundreds of other fibers in the nerve trunk. If, for example, you connected a telephone receiver to the whole of a telephone trunk cable carrying messages from thousands of different subscribers, you would gain little information from the jumbled babble of voices in your receiver. You require one circuit at a time. Likewise, most of our knowledge regarding the text of nerve messages has come from a study of what is transmitted over the individual fibers. This was first made possible by Professor Adrian, of Cambridge University, and his colleagues, who succeeded in cutting all but one or two of the many microscopic fibers in the nerve between their source in the sense organ and the place where they are connected by means of wires to the electrical recorder. Here a serious obstacle is encountered, because the electrical pulses are so small and of such a short duration that one would expect great difficulty in detecting them. Fortunately, however, it has been possible to overcome this difficulty because the progress of radio-telephony has required the development of vacuum tube amplifiers, or "electrical levers," capable of magnifying very small electrical voltages. The instruments perfected by the radio engineer to make possible the type of communication I am using this afternoon have been employed to amplify the nerve impulses more than a hundred thousand times. And so it has been a fairly simple matter to change these electrical pulses in the nerve into the movement of a beam of light recording on a photographic film or into sound issuing from a loud speaker.

It thus became possible to find out what passes up sensory nerves to the brain when sense organs on the surface of the body are stimulated. A small piece of skin, for example, is removed from an animal, together with an attached cutaneous nerve. Wires lead from the nerve to a vacuum tube amplifier, from that to an electrical recorder, and finally each amplified nerve impulse produces a flick of light which leaves its record on a moving photographic film. When we press upon the skin we find that the sense organs for pressure send over the nerve a series of impulses regularly spaced and of a definite frequency. This is the fundamental nature of the sensory nerve message.

The impulses from any one sense organ are all of much the same size and general character. And yet we know that somehow there must be differences in the message under different conditions because it is possible to distinguish differences in the intensity of the stimulus. How the information regarding the strength of the stimulus is transmitted over the nerve fibers may be shown by increasing the pressure on the skin with which we are experimenting. We then find that the impulses follow one another more frequently. The more intense the pressure on the skin, the light in the eye or the intensity of the painful stimulus, the higher is the frequency of the impulses transmitted over the nerve fibers, the range being from about ten to several hundred a second. That is one of the ways the brain is kept informed of what is going on without and within the body.

Every sense cell requires a certain intensity of stimulus in order that it may come into action. If we shine a weak light into the eye, only those receptors which are most easily stimulated will discharge impulses. If the light be made brighter, more of the cells will respond and consequently more nerve fibers will be conducting messages to the brain. And so, as the intensity of the stimulus increases there is an increase in the number of impulses going to the brain each second, both as a result of more frequent impulses in the individual fibers and a greater number of fibers conducting impulses.

The general character of these messages from various types of sense organs is essentially the same. But then you may well ask how are we conscious of different types of sensation if the messages from the pain or pressure receptors in the skin, the light receptors in the eye and the pressure receptors in the arteries are all so similar. There is still a great deal of uncertainty about this, but the different qualities of sensation and the different reflex effects resulting from different types of stimulation are probably largely determined by where in the brain the nerve fibers end, or to what part they deliver their impulses. There is likewise very little known about how these waves of electrical and chemical change ultimately produce the complicated experience of consciousness. These are questions for another day.

One very important result of many sensory messages is muscular movement, and of its nervous regulation we can speak with some certainty. If we pinch an animal's foot, or thrust a pin into it, the foot is withdrawn. The stronger the stimulus, the more vigorously will the muscles contract. How is this activity controlled? From what I have already said you know that the stimulus has caused a series of impulses to be sent to the brain over the sensory nerves—the stronger the stimulus the greater the number of impulses. In some manner they act upon the brain or spinal cord, which in turn modifies the degree of contraction of the leg muscles. This regulation of the contraction and that involved in the voluntary control of our own muscles must be carried out by means of nervous messages traveling over the nerves that go to the muscles, for if these nerves are destroyed or injured, such a contraction is no longer possible.

In order, therefore, to find out how the nerve cells in the brain and spinal cord regulate the contraction of the muscles these messages have been intercepted and recorded. We find them to be essentially the same as those in sensory nerves and to consist of a series of impulses which cause a contraction of that part of the muscle receiving the impulses. The muscle as a whole is built up of a very large number of microscopic cellular units or muscle fibers. Each of the many nerve fibers going to a muscle transmits impulses to a certain part of the total number of muscle fibers. If more nerve cells in the central nervous system send out impulses over their

nerve fibers, the additional muscle fibers receiving these impulses will contract, and consequently the tension developed by the muscle will increase. The increased force of the contraction is due, therefore, in part to an increased number of nerve muscle units coming into action.

There is another mechanism. A weak contraction is maintained by a series of nerve impulses coming to the fibers of the muscle at the low frequency of about five to twenty a second. Each time an impulse reaches a muscle fiber that fiber will contract, and after about one one-hundredth of a second again relax. During a weak contraction, therefore, the individual fibers twitch at a rate of five to twenty times a second. The whole muscle, however, does not show such a jerky contraction but functions smoothly. This integration of the twitches of the individual fibers into a smooth contraction is due to the fact that the impulses in the various nerve fibers do not all arrive simultaneously: some fibers are contrasting while others are relaxing. As the strength of the contraction increases we observe that it is due to an increased frequency of impulses coming to the muscle, the rate increasing to over one hundred a second in powerful contractions. Now it is easily shown that the tension developed by a muscle increases as one increases the rate of stimulation. At low frequencies the fibers are able to relax between successive contractions, but as the muscle is forced to contract more frequently there is less time for relaxation between successive twitches. The result is that the fibers remain contracted a larger part of the time and so the tension maintained by the muscle as a whole increases. In this way the variation and frequency of nerve impulses going to the muscle provides an additional and effective means for delicately regulating the degree of muscular contraction.

Such are the general characteristics of the nerve messages which give rise to sensation or which control the muscular activity of the body. They are a succession of impulses that are all of exactly the same size and vary only in the rate at which they follow one another. Information regarding a weak stimulus is transmitted to the brain over relatively few nerve fibers and the impulses in the individual fibers succeed one another at fairly infrequent intervals. Strong stimuli, on the other hand, bring into action more sense organs and each one discharges impulses more frequently. Thus, the intensity of sensation seems to depend on the number of impulses reaching the brain in any given interval of time. Similar messages dispatched from the brain to the muscles govern the movements of our body. To develop a powerful contraction, nerve impulses at a high frequency are sent out over many fiber pathways. To relax the muscles, fewer fibers are used and the impulses in each fiber are sent less frequently.

These are the fairly simple messages by which an intricate organism regulates its complex activities.

THE MAINTENANCE OF OUR MENTAL ABILITIES

By Dr. W. R. MILES

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THINK of yourself as you are to-day; then think of yourself as you were a year ago to-day. What skills, what knowledge, what interests, what basis for making better judgments, for getting enjoyment and giving it have you fully maintained or improved? Compare yourself with five years ago. Is the picture changed? Do you see improvement? If a hundred of such years were

placed end to end would it make a century of progress? Or a new low? Do you know whether the gains and the losses that you have made personally during the past year are due largely to inevitable physiological changes or to your own mental efforts and attitudes? Do you know what is to be expected, and what is to be hoped for in the way of maintenance and ability change at your age and with the capacity which you were given to start with?

The results of recent psychological investigations on adults give information about what changes people may be expected to undergo and how their abilities and interests actually test out from decade to decade. In infancy and childhood growth and development are nearly universal characteristics and the rate of improvement in sensory capacity, skill, understanding and judgment is tremendous from year to year. A motion picture showing in a single reel the development from birth to young adulthood displays such quick and important changes that we are surprised and filled with wonder. But what would a motion picture reveal that shows in yearly samples our characteristic activity from age 20 onward?

People have been talking about adult decline and the effects of age since the beginning of man's interest in himself. Just recently the conclusions arrived at by general observation have been checked by experiment; some of the myths and errors have been discovered and some of the truths defined and confirmed. At Stanford University and at Yale, extended experiments in this field have been carried on under my direction. We have studied more than 2000 adults between the ages of 20 and 95, with more and sometimes many more than a hundred representatives in every age decade below 80. It is chiefly from these studies that I am reporting results to you, because in these two laboratories the largest human population has been examined with the most varied program.

Other investigators have made very important studies of different phases of the age problem. Professor Thorndike at Columbia University has studied learning in adults, Professors Jones and Conrad at the University of California at Berkeley have studied the intellectual powers, and there are other notable contributions which you will find mentioned in a survey of this whole field of study which I reported in the *Psychological Review* for March, 1933, in an article called "Age and Human Ability."

From the Yale and Stanford studies, in which data on actual people in their actual doings can be compared from decade to decade, three impressive trends stand out for the period of maturity and beyond.

(1) Gradual decrease in skill generally occurs, but ability is substantially maintained where interest and practise are present.

(2) Decrease in physical energy and power is to be expected, but increase in organization and judgment may compensate.

(3) Decrease occurs in obvious external activity rate when meeting new situations, but with appropriate enlargement of interests and growth through experience increase in adequate integration of mental powers may be achieved.

If you could see the people themselves as they file by the psychological camera the significance of these conclusions would strike you, as it has me, with compelling force. Each of the two thousand persons who has so generously cooperated in the experiment has given, in a two- or three-hour period, a pretty clearly sketched picture of his or her mental make-up, mental habits, capacities, interests and skills. I wish you could see the great procession of these interesting human beings, including as they do people of every kind of talent and aptitude. They are representative of people in general except in one respect: they do not include unfriendly, uncooperative per-

sons, because all of these people wanted to help in this big experiment.

The personal identity of my cooperators must be guarded and the individual records are strictly confidential, but I am going to tell you a little about a typical person or persons in each of the different decades.

Here comes, first of all, the young man of 20; he is fond of activity, works well and persistently. His eyesight is good, his stand steady. His reaction time is quick, whether in old or new directions. He can turn quickly and effectively from one type of work to another. He is vigorous and enthusiastic, ready and eager for the task before him.

At 30 he seems much as he did at 20, except that he is somewhat steadier and more skilful in his chosen work. His interests are more definitely settled and he recognizes his own capacity more clearly. He is either continuing to extend his learning to include wider aspects of his work and more varied cultural and recreational possibilities or else settling into a routine of daily work and play suited to his present age but without the preparatory stages of cultural life interests which he will need later on.

Although there is this relatively slight difference at 30, two type men are pretty clearly defined at 40. The first is the man whom we saw at 30 skilful and steady in his work, and with interests broadening to include wider fields. He is as capable as ever in managing most kinds of material, just a little slower and more cautious in his reactions —for example, more careful in driving his car. He is somewhat more interested in getting on with his associates in a friendly way. He devotes time to reading and to thoughtful conversation about important problems. He knows about present events and the progress of science, politics, philanthropy, art or religion.

The other typical man of 40 is the man of routine who has changed comfortably in the direction of decline. He has added no new interests and skills and in those that he had, that inevitable physiological decline of age is beginning to appear. He dimly recognizes that he is slipping a bit and that the new is some way annoying to him; at times he pushes himself and tries to react as quickly as when young and thus sacrifices adequacy and appropriateness to speed. In temperament he becomes more irritable.

At 50 and a little more markedly at 60 each of the two types shows somewhat less clearness in vision, and a decrease noted in the speed of hand and foot is characteristic. Still the much practised skills are near the maximum in most cases, because usually in these experience compensates for the slight physical slowing down that has occurred. The representatives of the professions and occupations most dependent on physical power and bodily strength, including such widely diverse activities as truck driving, baseball playing and dentistry, feel the decrement most and most need the secondary interests and skills which they may, if they were wise, have developed outside the routine work which they follow to make a living. If they did not do this we see them now, as their manual and general physical skill declines, resorting to a life of fancy, telling of their old exploits and forgetting the present as they live over the past.

At 70 and at 80 we see those who in the earlier decades built out their interests and developed their skills not only for the immediate business of the day but also for the years when these skills tend to wane, as the counselors and advisers of younger men who have speed and dexterity but lack the experience of long years. To the fruits of their ripe maturity Cicero's remarks two thousand years ago apply: "Great actions are not achieved by exertions of strength, or speed, or by quick movement of bodies, but by talent, authority, judgment; of

which faculties old age is usually so far from being deprived, that it is even improved in them—." These counselors are really still young in the sense that youth means growth and development. Old are the men of 70 and 80 who had little or no interest beyond matters in relation to which age brings marked physical decline.

While the successive decades beyond the age of 30 years show for most things thus far measured, slow progressive decline in the averages, still there is really a large amount of person-to-person difference when we consider the scores of individuals. About 25 per cent. of men between the ages of 50 and 70 can perform mental and light manual tasks as well or better than average men 20 to 50 years of age; and fully 10 per cent. of to 70- to 90-year group can perform mental tasks as well or better than the average of the 20- to 50-year group. The large amount of overlapping in the abilities of successive ten- or twenty-year periods may give great hopes to all of us.

Of course, health plays a big part all through the years, but the training of mind which prepares for change may often diminish the influence of declining health. And so we may occasionally see the hale and vigorous 80- or 90-year-old participating with weight in the deliberations of community and state; contributing valuably from the experience and through the insight acquired in long years.

Only typical individuals have been described and this brief review has been limited to the men. The trends hold true for the women also, and I wish time would permit me to tell you now about them as they have been at least equally cooperative in going through our tests and measurements. I want here again to emphasize the fact that individual differences in both interests and skills are more conspicuous among both men and women than are age differences. Some of our oldest people can turn out better work than the average man or woman in early adulthood. The importance of this fact for industry and employment of all kinds is obvious. If the best utilization of the best abilities of human beings is to be made there can be no old age retirement dead-line. The individual and his actual contribution, not his age by the calendar, will eventually become our employment criterion.

In conclusion, we may say that maintenance of our mental abilities will not take place automatically. What each of us needs to do is pretty clear. We must adopt a maintenance attitude and recognizing that modern industry, and many of the professions, now more than ever, fail to fill up our time and to provide for full and continuous mental development, we must seek additional life avenues suitable to our individual interests and capacities.

(1) As our skill inevitably declines, but does so least where interest and practise are present, we must bestir ourselves with effective exercise along the special lines where we wish the decline to be least rapid.

(2) We may anticipate and compensate for the decrease in physical energy and power by early and continued efforts toward organization and the substitution of good judgment for bodily speed and strength.

(3) Since decrease is bound to occur in the obvious external activity involved in meeting new situations it becomes tremendously important to develop a wide range of interests and wide fields of knowledge so that there may be more places where effective integration and growth through experience may occur.

Aristotle said "Education is the best provision for the journey to old age," and we may add that there is no more important or interesting science of strategy than that required for the happy conduct of this journey.

MAN BEFORE THE DAWN OF HISTORY

By Dr. DAVID RIESMAN
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A NUMBER of years ago I saw in the British Museum a vase from Mesopotamia with an accompanying card giving its age as 4500 B. C. It was the oldest dated object I saw in the museum on that visit. I gazed at it long in contemplation—6,500 years old—it was difficult to believe, but that was before I became interested in prehistory. Since then I have held in my hand a crude stone object known as a hand-axe or coup-de-poing that was found in England and that by the accepted criteria of prehistoric science is from 200,000 to 500,000 years old.

What evidence have we that man's antiquity goes back to a time of such inconceivable remoteness? The evidence is in the main of four kinds. First, the discovery of man-made objects or artifacts in ancient strata that are geologically datable with reasonable accuracy. Thus J. Reid Moir has found flint tools imbedded in the Red Crag of East Anglia, a geologic stratum which, overlaid by a number of later deposits, may well be between half a million and a million years old. Secondly, parts of human skeletons have been found in layers belonging to the so-called Pleistocene epoch. The most recent of these finds and perhaps the most important of all is the completely petrified Chinese skull imbedded in a solid layer of travertine. From its depth below the surface and from other dependable criteria the age of this layer is estimated at a million years. Then, human remains, human tools and human works of art—sculptures and paintings—have been found in Europe in association with the saber-toothed tiger, the woolly mammoth, the rhinoceros, the lion, the reindeer and the cave bear—animals belonging to an era long, long past in central Europe.[1] Finally, apart from any geologic or stratigraphic evidence one can not contemplate the artistry of the cave-dwellers without feeling that an immensity of time must have elapsed from the first appearance of man on the earth until such astounding skill was attained. No longer can we consider the Babylonians or the Cretans as very ancient peoples. The first dynasty of Egypt, that of Menes, 4700 B. C., Tutankhamen, Solomon, Assurnasirpal are of yesterday, and patient Bishop Ussher was quite mistaken when after a laborious calculation he decided that the world had been created on October 9, 4004 B. C.

I shall not go into the details of the geologic time-table accepted by scientists but will merely point out that primitive man, speaking chronologically, lived in the epoch called Pleistocene or Quaternary, which is the age that directly precedes the present called the Psychozoic or Age of Man. The beginning of the Pleistocene goes back from 200,000 to 500,000 years. Preceding it is the so-called Tertiary, a geologic period of vast length during which the large land animals appeared.

We are greatly helped in differentiating successive "cultures" or eras of prehistoric man by a study of his tools. It would be extremely interesting to know how early in mundane time man began to make tools and other implements. The first tools were probably made of wood,

[1] Individual mammals of extinct species may have survived long beyond the time of the main stem of that species so that the finding of fossil mammoth or tiger bones, for example, does not warrant the conclusion that the contemporary humans go back to the time when these animals flourished in greatest number.

but they have not been preserved. Very early, however, man learned to use flint and other hard stone and to fashion them to his hand in a crude way by chipping. The resulting implements are relatively abundant and can be gathered in many places in Europe by a little digging beneath the surface and in caves and cliff hollows. In the oldest layers they are crudely chipped, but as we proceed to younger strata we find better and better workmanship. The French, who have so far done the most extensive work in prehistory, have used the stone implements as a basis for a systematic classification that is now generally adopted throughout the world. The names given are chiefly those of French towns or places where the particular type of stone culture or industry finds its best illustration. These are from above downward, that is, from the most recent to the oldest prehistoric age—Magdalenian, Solutrean, Aurignacian, Mousterian, Acheulian, Chellean, Prechellean. The series as a whole is known as the Old Stone Age or Paleozoic. The stone implements were made by chipping, hence they are rough. In the succeeding New Stone Age or Neolithic, they are smooth and polished.

Geologically, the Old Stone Age coincides largely with the Pleistocene epoch, a period during which occurred those tremendous glaciations or Ice Ages that swept down from the Arctic regions and covered vast areas of North America and Europe. Through Charpentier and Agassiz and their successors we know how profoundly the Ice Age has affected the present-day landscape as well as the fauna and flora of the temperate zone. The individual ice ages were separated by warm interglacial periods, during which the land was habitable. Evidence is accumulating that man was unquestionably living on the earth in the first interglacial period; and there is good reason for believing that he existed long before—in the Pliocene, the last epoch of the Tertiary.

Before I speak in detail of the Men of the Old Stone Age and their handiwork as it can be seen in the South of France, I want to discuss briefly the short annals of the science of prehistory. Fossils had been known since the time of Herodotus, but their meaning was not guessed until Leonardo da Vinci, the omniscient, recognized in them the petrified remains of once living organisms. But, like much else the fertile Leonardian brain suggested, the matter of fossils was forgotten. Johann Berringer, the Wurzburg professor in the eighteenth century, looked upon them as objects placed in the ground by God himself to test the faith of man. When John Frere, in 1797, found in an ancient brick field in Suffolk, England, some hand-shaped flints and recognized them as human products, no one paid any attention to him. Dean Buckland, reader in geology at Oxford, in 1822 found in a cave at Paviland in Wales the remains of the rhinoceros, the cave bear and other extinct animals side by side with human bones. He attributed their joint presence to the Deluge. This reminds one of Asa Gray's explanation for the extinction of the mastodon —it was too big to go into the Ark.

In 1826 the Reverend Dr. T. MacEnery, a Catholic priest, found similar fossil remains in Torquay, in association with stone implements. He drew the correct conclusion that man must have lived in England contemporaneously with the mammoth and the rhinoceros, but he did not dare to publish these conclusions during his life, and they did not appear until sometime after his death.

In 1823 Boué sent to the celebrated Cuvier a human skeleton exhumed near the banks of the Rhine. Associated with it in the loess strata were remains of a number of extinct animals. Cuvier utterly failed to appreciate the significance of this discovery and rejected it

as being of no importance. Several other isolated finds of similar nature were made but challenged no one's interest. Then came a man who may well be called the father of prehistoric anthropology—Boucher de Perthes (1788–1868), director of customs at Abbeville. He found a number of what he called antediluvian axes and identified them as the work of an extinct race of man. Like Pasteur a generation later, he was ridiculed by the academicians. But those who derided him as a dreamer and ignoramus are forgotten while Boucher de Perthes is enthroned among the immortals.

Probably the most important date in prehistory is 1856, the year in which a modest German professor, Dr. C. Fuhlrott, found a skull cap and other human bones in a cave in the Neanderthal, near Düsseldorf on the Rhine. These bones, found as they were in association with those of animals of extinct species, created a sensation. Fuhlrott, Huxley, Lyell, King and Broca saw in them the remains of a primitive human type, but Virchow considered the peculiar appearances as due to disease, and by his great authority silenced his opponents. But as time passed similar finds were made elsewhere, particularly in Southwestern France, and we now know that they as well as the original Fuhlrott bones represent a widely disseminated race called after the place where the original skeleton was found, the race of the Neanderthals—*Homo Neanderthalensis.*

About 1894 Eugene Dubois, a Dutch army surgeon, discovered at Trinil, on the island of Java, the top of a skull, some teeth and a thigh bone which he believed were the remains of a sort of missing link and which he designated by the now famous name *Pithecanthropus erectus.* In close proximity he found parts of more than twenty-four species of mammals totally extinct. Although his discovery attracted world-wide attention, Dubois for many years absolutely refused to have any one see the originals, but recently he has become more complacent and has exhibited them to a number of scientific men, including Professor MacCurdy, of Yale.

The Java or Trinil man, as Pithecanthropus is also called, has evoked a great deal of discussion. The skull, as reconstructed by MacGregor, has a capacity of about 900 cc; that of modern man 1,500; that of the Indian Veddhas and of the Papuans of New Guinea 1,230 to 1,250 cc, while that of the highest ape has a content of only 600 cc. Thus the Pithecanthropus is about midway between the highest anthropoid and the lowest human. There is much discussion as to the geologic age to which Pithecanthropus should be assigned. Dietrich, Osborn, Elliot Smith and MacCurdy place the Trinil man in the Pleistocene period, but others, who find the associated animals to be of an earlier age, put Pithecanthropus in the Pliocene. A lower jaw fragment has recently been found some twenty-four miles distant from the spot where Pithecanthropus was discovered. If it belongs to a second individual of the same genus, it suggests that the Java man had a lower jaw of slight build and an almost vertical chin. The skull cap is marked by expansive, heavy brow ridges.

One of the most revered of prehistoric relics is the famous Heidelberg jaw found in 1909 by Professor Schoetensack in the Maurer sandpit near Heidelberg at a depth of 82 feet below the surface. It is not strictly a human jaw, for it is too large and possesses, besides other minor anthropoid characters, a strikingly receding chin. Its age is estimated at between five hundred thousand and a million and a quarter years.

In 1911–1912 Charles Dawson discovered near Piltdown, Sussex, an incomplete skull and lower jaw, which from many points of view constituted, until

1929 at least, one of the most important of all prehistoric discoveries. The skull is unquestionably human, with a brain capacity of 1,240 cc. The lower jaw, however, as one writer puts it, has been a bone of contention since its discovery. Some think it is too simian to belong to the Piltdown skull. Recent finds, however, in the same region make it highly probable that the jaw belongs to the skull and not to an anthropoid. Piltdown man, whom Woodward has designated *Eoanthropus dawsoni* (Dawn-man), had a receding chin, prominent canine teeth and low brow ridges—he differed thus considerably from the Java man. In close association with the Piltdown skull Dawson found a quantity of flints, crudely chipped, which he called Eoliths, believing them to be the handiwork of the Piltdown race. Many have disagreed with him, attributing the chipping to natural breakage, but belief is growing, largely through the investigations of J. Reid Moir of Ipswich, that they are true artifacts. Although placed at first in the Pleistocene, Sir Arthur Keith, Newton, Dawson and others are convinced that Piltdown man is of Pliocene age, a conclusion that places early man in England at a time of enormous remoteness. And if we accept the mute testimony of the Eoliths taken from exceedingly deep geologic strata in England, then the recently announced estimate of Professor Hooton that man goes back to the second half of the Pliocene, or about four million years, does not seem altogether out of reason.

In 1921, a skeleton of Neanderthal type was found in the Broken Hill mine in Rhodesia. More recently Professor Dart found at Taungs, northwest of Johannesburg, in a limestone cliff at a depth of 50 feet, the skull of a boy that possesses both human and simian characteristics. The name of *Australopithecanthropus africanus* has been given to this species. Since then other interesting finds have been made in Africa recalling the prediction of Darwin that Africa might be found to be the cradle of mankind.

Perhaps the most important recent African discoveries are those of Professor Reck and Mr. Leakey at Oldoway in Kenya Colony. Professor Reck had unearthed a skeleton of an apparently modern type man in 1913. If contemporary with the animals with whose petrified remains it was found, it indicates a very great age for *Homo sapiens*, at least in Africa. The matter is still in dispute, but the recent explorations of Mr. Leakey in Oldoway seem to bear out his contention that Professor Reck's skeleton is of lower Pleistocene age.

While an African origin for man is in the realm of the possible, the majority of scientific men lean to an Asiatic ancestry. Osborne and his associates in the American Museum have been consistent advocates of this view and have had its confirmation as one of the main objectives of their several expeditions into the Gobi Desert. Fortune was not with them, however, but instead smiled upon a young Chinese geologist named W. C. Pei, who on the last day of a season's excavations, on December 2, 1929, made the most famous of all prehistoric discoveries. Imbedded in travertine and completely petrified, he found an uncrushed skull of a woman. After careful study—it took months to remove the stony encasement—Professor Davidson Black, of the Peking Medical School, and Professor G. Elliot Smith came to the conclusion that the skull represents an early type somewhere between Trinil man and Piltdown man or even an earlier species. The thick skull has more massive brow ridges and a greater skull capacity than Pithecanthropus. Geologically, *Sinanthropus pekinensis* belongs, according to Father Teilhard de Chardin and Dr. C. C. Young, to the lower Pleistocene or Polycene and may

easily have an antiquity of a million years. In a communication just received from Professor Elliot Smith he calls attention to the evidence discovered by Mr. Pei that Sinanthropus knew fire. Charred objects were found in deep travertine deposits. These startling discoveries of Mr. Pei have been confirmed by Abbé Breuil, who last October made the arduous journey to Peking for the purpose of studying the evidence accumulated with respect to Sinanthropus.

Abbé Breuil holds that *Sinanthropus pekinensis* is not the being devoid of human faculties that he was at first supposed to be in view of the approach of his skull to that of the Anthropoids, but despite his animal characters he is already "man," with a progressive intelligence and the beginning of supremacy over other animals by virtue of his knowledge of fire and of working in stone. He is by no means the last step toward humanity nor is he the first—the point of departure is much farther back. This man with his technique and practical science had numerous human ancestors, of whom we know absolutely nothing.

By the end of 1930 the finds in China had reached five jaw fragments and the same number of skull fragments, a large series of teeth, but curiously no human limb bones have so far been discovered. Large quantities of fossiliferous material, implements of bone, quartz and quartzite have also been found. We have no knowledge of the place where Pithecanthropus and Eoanthropus lived, the few broken fragments of their skeletons that have been found having been deposited either by running water in the gravel of a river-bed, as at Piltdown, or in the tufaceous bank of a stream, as in Java, but in the case of the Peking man, he must actually have lived in the cave where his petrified remains were found.

Within recent years many important discoveries in prehistory have been made in Czecho-Slovakia. In the summer of 1930, at the suggestion of Professor and Mrs. Absolon, the well-known prehistorians, I paid a visit to Brno (Brünn), the capital of Moravia. Here under the inspiration of Professor Absolon a splendid prehistoric exhibition called "Anthropos" was in progress. I had known something of the activity of the Czechs in prehistory, but I was in no way prepared for the wealth of recovered material I saw in Brno. There were enormous quantities of fossil remains of the mammoth, the tiger, the lion, the rhinoceros and also human skeletons, as well as flints and other stone artifacts of every conceivable kind.

While there has been some dispute as to the proper assignment of the Moravian culture, the majority of scientific men agree with Professor Absolon that it is Aurignacian. Unfortunately, the national pride of the Czechs, in a measure justified by the signal progress of their newly established republic, impels them to publish everything in their native language, which by its very looks frightens off those not born with a Slavic tongue.

While at Brno I decided to pay a visit to the Augustinian cloister of Gregor Mendel. As my guide in the "Anthropos" exposition, Mr. Skutilh, had himself never been there, he gladly volunteered to accompany me. Unhappily we arrived after twelve o'clock and were informed by the affable monk who received us that the Mendel apartments were closed at noon. However, he would see the abbot. This worthy successor of Mendel gave permission to open the hallowed rooms, enabling us to inspect Mendel's library, his microscope and many other relics. I then asked to see the garden, in the hope of finding living descendants of Mendel's famous peas. Not a single one remained, only a tall tree that he had planted. I got the impression that the cloister was not greatly

interested in Mendel's scientific work. On parting I casually inquired of our kind host whether they had many visitors. "Not many," he said. "Whence do most of them come?" His answer amazed me. "The majority," he said, "are Japanese."

Interesting finds have within recent years been made in Palestine. Miss Dorothy Garrod has found in the cave of Shukba a vast quantity of Neanderthal remains, among them a number of skulls from which pieces had been cut out, similar to the mutilated brain cases recovered from a quarry at Ehringsdorf near Weimar. The inference has been drawn, not unreasonably, that the holes were made by our cannibalistic ancestors for the purpose of extracting the brain. In the Shukba cave and in many other places long bones have been found that were evidently broken by a sharp instrument while in a fresh condition, apparently for the purpose of obtaining the marrow.

A number of startling discoveries have been made in Palestine since the beginning of this year. Professor MacCurdy informs me that nine skeletons of Neanderthal men have so far been found by Theodore D. McCown, of the British School of Archeology. Miss Dorothy Garrod believes that the skeletons are of Neanderthal type, although differing somewhat from the Neanderthal man of Western Europe. The hands have the characteristics of modern man, but the feet and thigh bones have not.

It is rather interesting that despite an almost feverish activity on the part of digging scholars the actual quantity of prehistoric human remains so far unearthed is comparatively small. The question naturally arises, "Why are the remains of early man and his precursors so rare?" Chiefly because primitive humans did not embalm or bury their dead. Consequently, the cadavers were devoured by wild beasts or rotted on the ground. You remember the grave-digger's answer when Hamlet asked him, "How long will a man lie in the earth ere he rot?" "In faith if he be not rotten before he die—as we have many pocky corses nowadays, that will scarce hold the laying in—he will last you some eight or nine years; a tanner will last you nine years." Shakespeare might be surprised to know that some bones interred accidentally or on purpose more than twenty thousand years ago have lasted until now. Survival, if one may use that word in connection with dead bones, probably depends upon the nature of the soil. The accidental fall into a river bed or in soft mud could easily bring about the preservation and fossilization of isolated skeletons or skeletal parts. Man, however, seems to have begun quite early to bury his dead, certainly in the latter part of the Old Stone Age, thus helping to preserve for us a number of skeletons of inestimable value to the science of prehistory.

I ought not to pass over in a historic retrospect the year 1859, which witnessed the appearance of Darwin's "Origin of Species." Sir Arthur Keith, in his presidential address at last year's meeting of the British Association, reemphasized in strong anti-Daytonian phrases the important bearing of Darwin's work upon the study and comprehension of the descent of man.

I now want to take the reader to France, for it is there that the prehistorian finds more to interest him than anywhere else in the world. While a large part of France is rich in prehistoric sites or stations, as they are called, the real capital of the prehistoric world is the pleasant little town of Les Eyzies in the Dordogne. Through the courtesy of Professor George Grant MacCurdy, director of the American School for Prehistoric Studies, I was enabled while in Europe to join the school for a brief stay in the romantic village of Saint Léon-

sur-Vézère. The Vézère, a tributary of the Dordogne, is a silent dreamy river. Standing on its banks I had an overpowering sense of mystery—I was conscious of an antiquity with which that of the Roman Forum and the Egyptian Pyramids can not be compared. There is a fine little museum in Les Eyzies, containing quantities of artifacts and human fossils found in the region. The town is also noteworthy for its war monument, which is one of the best I have seen. The artist with an understanding of the genius loci has carved upon the granite boulder a youth who with one hand crushes a prehistoric bison and with the other strangles a German eagle.

In the vicinity of Les Eyzies are a number of world-renowned prehistoric caves which penetrate deeply into the hillsides and must have afforded a wonderful shelter for the cave man. I can not in words describe the impression made upon me by the pictures painted and graven on the walls in those caves. Only once before in my life did I have a similar experience—at my first sight of Saturn through a telescope.

In the "Prometheus Bound" of Aeschylus I discovered an interesting passage that shows how profound and true a conception the poet had of the primeval life of man, a conception that did not again rise into man's consciousness until 2,400 years later. He says, "Knowledge had they neither of houses built of bricks and turned to face the sun, nor yet of work in wood; but dwelt beneath the ground like swarming ants, in sunless caves, ἐν μυχοῖς ἀηλίοις."

All the caves are interesting, and each has a character of its own. Among the most thrilling is the one called Grotte des Combarelles. There is a small fee for admission. Three of us entered, guided by a peasant woman, who knew her story and rattled it off remarkably well. We carried flat sticks with a tallow candle at the end. The floor of the cave is muddy and slippery, the walls come close, the ceiling is so low in places that we had to crouch for long stretches. From the entrance until we stopped to turn back was about one thousand feet. Through that whole length both walls are covered with drawings in black and white of animals—the reindeer, the mammoth, the cave bear, a species of horse, the bison, all done with an overwhelming realism. A few strokes indicate that the mammoth was woolly. From the Grotte de Combarelles we went to the equally interesting Font de Gaume. This particular cave belongs to the local laird, who has had it electrically wired. It too contains many vividly artistic drawings, some in colors. Many of the pictures in Combarelles and in Font de Gaume have become well-known through reproductions. Although fewer are in polychrome than in the famous cave of Altamira in Spain, in artistic finish and realistic expression they are no less striking.

Who were the men who made those wonderful life-like drawings, unrivaled in their fidelity to nature? How were they able to draw and to carve so skilfully in the depths of a damp and sunless cave? What motives prompted them to what must have been slow and gruelling labor? These and other questions passed through my mind as I gazed upon the pictures. The first question may be answered by saying that the cave painting race belonged to the later Paleolithic epoch, to the Aurignacian and Magdalenian, also called the Age of the Reindeer, of which the Cromagnon is the most imposing representative. He was of good stature, had a fine head, and in practically every physical respect, and we must presume in mentality, the first to deserve Linné's designation of *Homo sapiens*. On the other hand, Mousterian man, his predecessor—how far removed in time we do not know precisely—was

an inferior being, prehuman in the anatomic and cultural sense.

Prehistorians were for a long time puzzled as to what sort of light the Aurignacian artist employed during his work. There is nowhere any evidence of soot. It is conjectured that he used an animal oil, either on a torch or in a shallow dish like that used by the Eskimos, as pointed out by Sollas and by Hauser. Much has been written as to the possible motives of the painters and sculptors. Was it art for art's sake? The majority of writers do not think so. They look upon the painting and sculpture as motivated by magic or sorcery. One of the pictures of a man disguised as a beast is strongly suggestive of this. Moved by theurgic beliefs that graphic representation of an object could give control over it through magic, they may have drawn images of the beasts that served them as food so as to promote fecundity. This idea is brought out in the novel called "Bison of Clay," by the son of the well-known prehistorian, Count Beguën. It may account for the fact that by far the greatest number of animals pictured are food animals. On the other hand, the same magical control might be secured over dreaded beasts of prey by similar means, that is, by visible representation. Such beliefs prevail among primitive peoples to-day and even among some that are looked upon as civilized.

If pictorial representation was used to promote fertility, the rarity of the human figure on the cave walls might perhaps be explained as a sort of Paleolithic birth control. Under the conditions of life in the cave—not unlike those prevailing in this era of grace—every additional mouth to feed was an unwelcome burden. The few human figures that have been found are chiefly those of the female, and are far less artistic than the animal pictures. They have small heads, large, pendulous breasts and huge buttocks, like the Hottentots. Is this figure a mythical or symbolic expression of fecundity or is it a realistic representation of the Aurignacian Venus?

As an amateur I ought perhaps not to express an opinion, but I could not escape the feeling that the cave art as well as the engraved bone and stone implements and ornaments represent a real urge for artistic expression, a hypothesis that does not contravene or exclude other motives.

Primitive man made use also of another kind of protected home, the so-called rock shelters, deep natural excavations in the sides of cliffs. A typical rock shelter is that of Laugerie-Basse, which is quite extraordinary in that it is possible to identify in its superimposed layers nearly all the old stone epochs. The thin compressed strata remind one of a layer cake, with layers rich in relics separated by sterile ones. In Laugerie-Basse, as almost nowhere else, one can trace without interruption all the ages of man in France—the Paleolithic, the Neolithic, the Gallo-Roman, the Middle Ages, and the present. Few places in the world have been inhabited by man for so many thousands of years without interruption.

Before leaving the Les Eyzies region we paid a brief visit to the village of Cromagnon, one of the holy places of anthropology, for it was here the famous Cromagnon man was discovered in 1868, during the construction of a railroad. There is, however, little of interest left in the sparsely settled village. Recently a statue has been erected at Les Eyzies to represent the Old Man of Cromagnon. It does not picture him as an Adonis; the long-armed slouching gorilla-like figure hardly suggests the talented painter of Font de Gaume or Combarelles. But after all the artist's fancy has nothing to do with unrecoverable reality.

Buried skeletons of a race similar to

the men of Cromagnon but shorter in stature have been found in considerable number at Grimaldi near Mentone. The physical characters of the Grimaldi race are suggestive of a negroid admixture—this is also true of the taller race—which is not surprising in view of the probability of the existence of a land bridge to Africa in prehistoric times. Sir Arthur Keith, I may add, does not believe that Cromagnons had negroid characters because they were hybrids. As a "Unitarian" he would explain the evolution of the human race on the basis of a common ancestor, and that it was only after dispersion that the differentiation occurred into the black, yellow and white races of mankind.

The Cromagnons or Aurignacians lived in Europe not later than 20,000 years ago. They seem to have migrated into Europe, for until the end of Mousterian time Europe was inhabited by the Neanderthals. The Aurignacian tools and implements are of far higher order than those of the preceding Mousterian. Cromagnon man, according to MacCurdy, was the first to reach the stage of making tertiary tools, that is, tools requiring the use of primary—found ready to hand—and secondary tools for their manufacture. They were used for an ultimate purpose other than tool making. The Solutrean industry, although later in time, is marked by a perceptible decline in art, except in one respect—the spear points and harpoons show a workmanship that for sheer beauty and symmetry can not be matched by the most skilful artisan of to-day. The laurel leaf and willow leaf flints of Solutré are a joy to behold. Recently a number of implements made of rock crystal have also been found.

The Aurignacian and Magdalenian man had also begun to make ornaments—pendants and beautifully carved commander sticks (*baton de commandement*). No doubt he made use of wood in many ways, but those utensils naturally have not been preserved. Old Stone man apparently had no writing; a few linear strokes upon tools and weapons may indicate an idea of number. The inscribed tablets of Glozel,[2] which some refer to the Magdalenian period, are of questionable authenticity.

What about our own continent? Ancient human remains have been found in America, but whenever it was possible to determine their ethnographic position, they turned out to be Indian of the same type as that now living. No doubt man has been on this continent for many ages, but the human remains are not like those of primitive man in Europe. Quite recently Cook and Hay have found in Folsom, Nebraska, and in Colorado, in strata that they identify as Pleistocene, flint artifacts in association with the bones of extinct mammals—bison, lion, elephant, etc. Whether the conclusion is warranted that the makers of these artifacts and the now extinct mammals were contemporary can not be definitely stated at this time, but a number of paleontologists do not agree with Cook's ideas as to the age of Folsom culture and agree with Hrdlička that no evidence of prehistoric man in the European sense has ever been found in this country. The famous tooth, which was first considered to be the relic of Osborne's *Hesperopithecus haroldcookii*, later was admitted by Osborne and by Gregory to be the tooth of a peccary, an extinct species of pig. Edgar B. Howard, of the University of Pennsylvania Museum, has made some interesting finds bearing on the question of American prehistory in the Guadalupe Mountains, and only a few days ago the statement was telegraphed from Florida that an arrow head had been found in a mammoth skull. The implications of these things are so far-reaching that we must know more about them before drawing any conclusions.

After a lapse of time similar to that

[2] Riesman, "The Story of Glozel," *Science*, lxxii, 1858, pp. 127–131, August 8, 1930.

which separates us from the cave man of Europe, what will *Homo sapientior* think of us of the twentieth century, of our wars and hatreds, our economic and political ineptitude, our want and suffering in the midst of plenty? Will he place us in culture nearer to the Cro-magnon than to himself? Who can guess? But no matter how dark the immediate future may appear, man's past achievements are colossal and an earnest of an infinitely greater civilization, the full possibilities of which are beyond our present imagination.

NATIVE BIRD TRAPS OF FRENCH INDO-CHINA

By Dr. JOSSELYN VAN TYNE

CURATOR OF BIRDS, MUSEUM, UNIVERSITY OF MICHIGAN

WHILE collecting birds in French Indo-China in 1929 with the Kelley-Roosevelts' expedition I was much impressed with the skill and ingenuity shown by the natives in trapping wild birds. Although certain inherent difficulties prevented much progress, it was possible to learn the details of some of their methods.

I am indebted to Mr. Stephen C. Simms, director of the Field Museum of Natural History, for his kind permission to publish this material and to use the photographs secured by the museum's expedition. Miss Grace Eager, staff artist of the University of Michigan Museum of Zoology, has skilfully interpreted my rough field sketches.

PITTA LIVE-TRAP

The Thai hunters of Muong Moun, Tonkin, were very fond of the meat of the large brown pittas of the region (*Pitta soror* and *Pitta nepalensis*), but when we offered the exorbitant bounty of twelve cents apiece for that special desideratum, they apparently brought us all their catch. Although pittas were

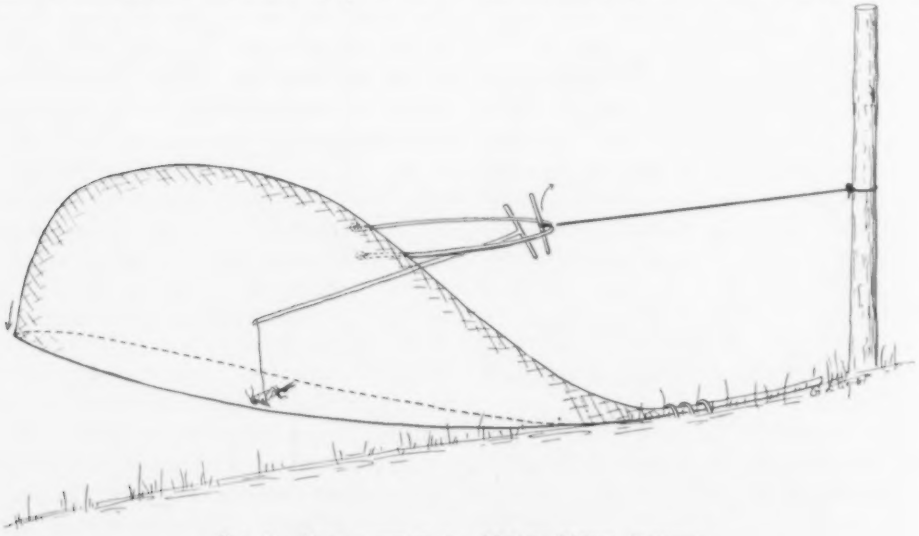


FIG. 1. PITTA LIVE-TRAP. MUONG MOUN, TONKIN.

so shy and secretive that we almost never shot or even saw one, the natives trapped and brought us twenty-eight in three weeks. When we asked through interpreters to be told the secret of their trapping methods, they refused, thinking that we wanted to do our own trapping and so save money. It was only when we were about to leave and had stopped buying pittas that they consented to show us how it was done.

As shown in Fig. 1, their pitta traps were essentially "box traps" made of split bamboo basket-work. The ends of the bamboo splints which extended from the base of the basket were pegged flat against the ground, thus forming a very effective spring to snap the basket down when the trigger released the supporting cord. When set, the front edge of the trap was held about six inches above the ground, exposing the bait in plain view to any unsuspecting pitta that might come down the little runway which led past the trap. A native showed me two such traps set about fifty feet apart in a little grove of second-growth beside a stream just beyond the limits of the village. One was baited with a live cricket and the other

FIG. 2. PORTABLE SPRING-SNARE. PHONG SALY, LAOS.

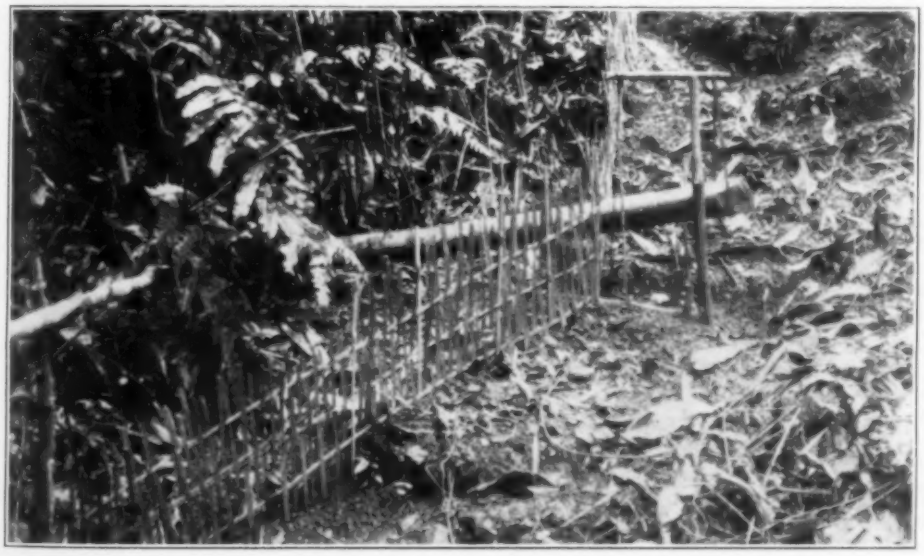


FIG. 3. PHEASANT DEADFALL NEAR MAKOMEN, LAOS.

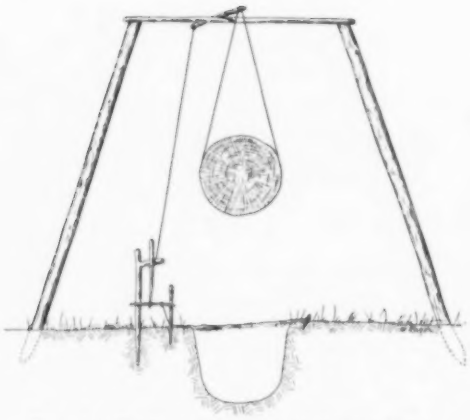


FIG. 4. PHEASANT DEADFALL MECHANISM. MUONG MOUN, TONKIN.

with a tiny live frog suspended by a thread about its waist.

PORTABLE SPRING-SNARE

The only elaborate portable trap noted was this ingenious demountable trap commonly used by the Pu Noi hunters of Phong Saly, Laos. The drawing (Fig. 2) shows the trap set. A bright berry is caught in the adjustable loop at the end of the trigger and then the trap is set in the grass in such a way that a bird can approach only from the side toward the spring and has to reach through the noose to get the berry. As indicated in the drawing, the spring stick (usually about 28 inches in length) is merely set in a hole in the bamboo foundation stick and is held in place by the tension on the cord attached to its end. To fold the trap, the spring stick is first unshipped and then inserted into the hollow end of the foundation stick, so that in the folded trap the foundation stick forms a sort of scabbard for the spring stick. The fiber triangle which surrounds the noose is then folded flat against the foundation stick and the trap has become a straight, compact object readily transported. In fact, we often saw Pu Noi hunters carrying large bundles of these folded traps.

DEADFALL TRAP

Near the Thai village of Muong Moun, Tonkin, I saw an interesting series of deadfalls in a little grove of bamboo. There was a series of five deadfalls in a row, spaced at intervals of about thirty feet and connected by a little bamboo stockade some two feet high. The stockade extended across a narrow neck in the grove and the only gaps in this fence were the five guarded by deadfall sets arranged as shown in Fig. 4. The deadfall logs were five or six inches in diameter and quite heavy. When released the log was arranged to fall into a trench of just sufficient size to hold it. When setting the deadfall, the native trapper had completely hidden the trench by a cleverly arranged false floor constructed of twigs and leaves. These traps, we were told, were designed especially for pheasants, but

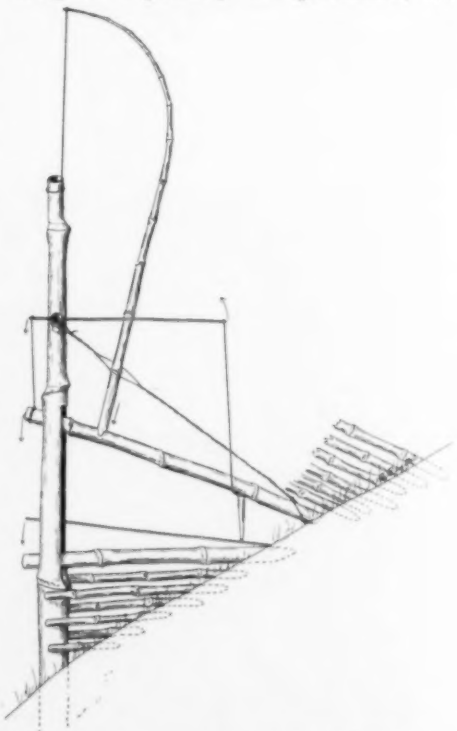


FIG. 5. SCISSORS-TYPE TRAP. MAKOMEN, LAOS.

we also found a bittern (*Gorsachius melanolophus*) and a large porcupine in this set. The three common pheasants of the region were the silver pheasant (*Gennaeus nycthemerus*), the jungle fowl (*Gallus gallus*) and the peacock-pheasant (*Polyplectron bicalcaratum*).

My companion, Russell Hendee, found another such series of deadfalls set by the Pu Noi hunters of the village of Makomen (near Phong Saly), Laos (Fig. 3). I was not able to examine the Pu Noi traps, but, judging from Hendee's photographs, they seem to differ but slightly in the method of suspending the log.

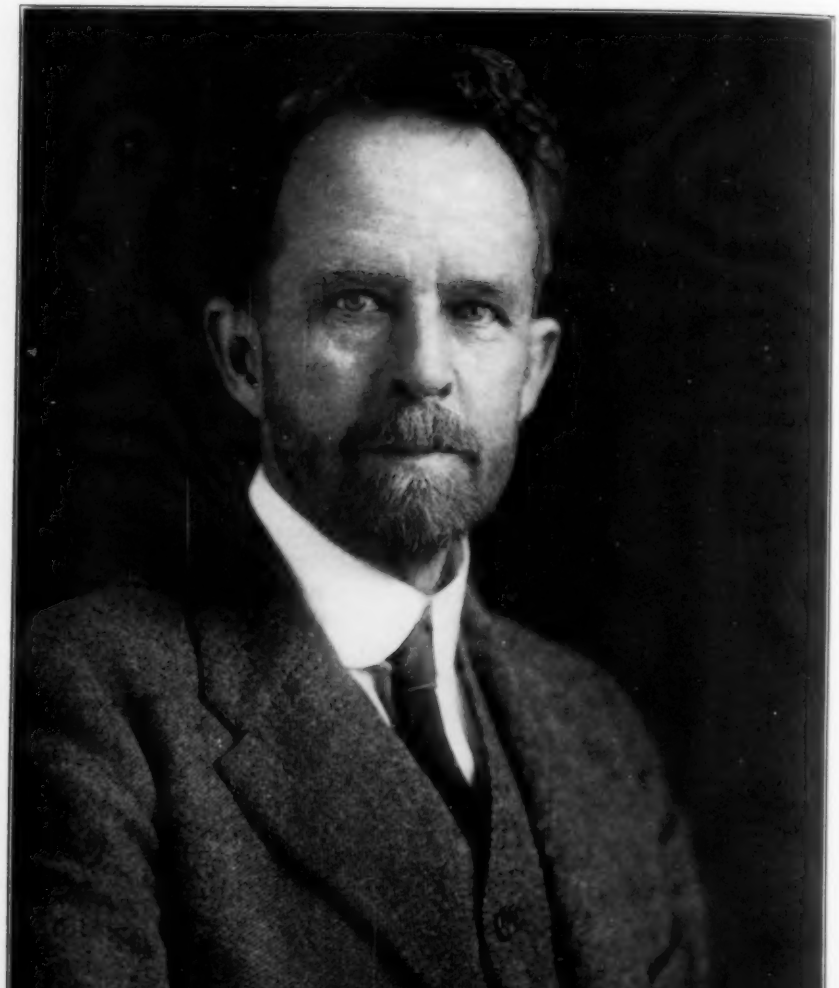
An excellent photograph of a similar pheasant deadfall as used in Burma was published by Beebe in his "Monograph of the Pheasants" (2, p. 84). It is interesting to note that Macpherson in his "History of Fowling" (1897) devotes the greater part of two chapters to an account of methods used throughout the world for catching pheasants, but barely mentions the use of pheasant deadfalls "in certain districts."

Scissors-type Trap

Perhaps the most interesting of all was the scissors-type trap (Fig. 5) found in a wooded ravine between Makomen and Phong Saly, Laos. Set across a little game trail which ran along the slope of the ravine, the paling above and the cut-bank below, left the bird or mammal wishing to pass no easy choice but to pass through the hole in the trap. A peculiar feature of this trap is that the usual method of arranging the bamboo spring is completely reversed. It was no longer in use when I saw it and I could not learn from the natives about its use, but from the lightness of its construction it was obviously meant only for birds or very small mammals.

This trap is essentially similar to a Philippine trap figured by MacGregor and Gardner,[1] a fact which suggests one of the reasons for placing on record such fragmentary data as are contained in this paper.

[1] *Condor*, 32: 95, 1930.



THOMAS HUNT MORGAN

THE PROGRESS OF SCIENCE

THOMAS HUNT MORGAN, NOBEL LAUREATE

THE award of the Nobel Prize to Thomas Hunt Morgan, in recognition of his fundamental work in genetics, will be received with satisfaction by all investigators in genetics, and by every one who is intelligently interested in heredity and variation or in the advancement of sound knowledge in biology. Morgan's work has laid a foundation on which all further development of knowledge of heredity, variation and evolution must rest. And he and his associates have constructed on this foundation a great edifice of detailed knowledge and understanding; a body of knowledge that has wide implications for the life of man and for general biological theory.

The thoroughgoing investigation of a single species, the fruit-fly, *Drosophila melanogaster*, has contributed most to this knowledge, although Morgan's work has ranged over many other fields. He is the experimentalist *par excellence*, an unwearied, driving worker, tenacious of purpose, following the objective evidence to the end, and courageously (at times audaciously) drawing the conclusions to which it leads—sometimes in face of universally opposing opinion—with a sureness that is justified by later developments. He has gathered a group of brilliant associates who carry on his methods and share in the discoveries that they yield. His methods of work, even in detail, have indeed spread throughout the world. So thorough has been the analysis of Drosophila that this organism now forms an unrivalled instrument for the solution of problems in heredity, variation and development. It is now worked on, further developing Morgan's methods, in many laboratories in every country of the world where biological knowledge is cultivated; it continues to yield results of fundamental interest.

The writings of Morgan and his associates include a great number of scientific memoirs, largely published by the Carnegie Institution of Washington, and many influential books in which the results of their investigations are summarized and brought into relation with the rest of biological knowledge. Morgan's scientific interests have not been limited to genetics; experimental embryology was his first love, and to this he returns at intervals. He has made extensive and important contributions in this field, including a number of books on the subject.

For many years he was professor of experimental zoology at Columbia University. Since 1928 he has been professor of biology and director of the William G. Kerckhoff Biological Laboratories of the California Institute of Technology. Much of his work has been done at the Marine Biological Laboratory at Woods Hole, Mass., where for many years he has been a member of the staff.

Morgan's associates know him as a man of strong individuality, with crisp, vigorous and humorous speech, and with sharply defined opinions that are quickly and forcibly expressed, but readily changed as objective knowledge increases. His work has not lacked recognition. Within the last five years he has been president of the National Academy of Sciences, president of the American Association for the Advancement of Science and president of the last International Congress of Genetics. To this group of high distinctions is now appropriately joined the Nobel Prize.

H. S. JENNINGS

ALFRED NOBEL

THE CENTENARY OF ALFRED NOBEL'S BIRTH

In October of this year there was celebrated in Stockholm the centenary of a man whose name is familiar the world over in connection with the magnificent legacy he left in the interest of human advancement. The man is Alfred Nobel, the founder of the Nobel Prizes awarded in science and literature, and for peace. While most widely known for that posthumous benefaction, his name also carries other associations, for Nobel spent his life in scientific pursuits and made a number of important discoveries, among which that of dynamite became epoch-making. His life-work and legacy were integrated into one continuous unselfish service to mankind by the fact that the latter represented practically his total accumulated earnings on the exploitation of his inventions.

Alfred Nobel was born in Stockholm on October 21, 1833, coming of an old Swedish family descended in the distaff line from the famous seventeenth century naturalist and mechanical genius, Olof Rudbeck. His father, Immanuel Nobel, an architect and instructor in mechanical drawing, became noted in Sweden as an inventor, but because of financial reverses emigrated to Russia, where he established a workshop in St. Petersburg. He invented, among other things, a submarine mine, and soon became purveyor of ordnance to the Russian Government, which position brought him affluence.

As a young boy Alfred followed his father to the Russian capital where he received a careful education, which was complemented by a trip to the United States, about 1850, and advanced studies in Paris. On his return to St. Petersburg, he was employed, together with his brothers, in his father's workshop. His chosen field was chemistry, and influenced by the nature of his father's business he now began to devote himself to research in explosives. His attention was drawn to the recently discovered nitroglycerin, and especially in the years 1862 and 1863 he was engaged in attempts to produce that unstable substance for use as an explosive in blasting. In that connection he worked out the principle of initiating detonation, first constructing a powder and fuse igniter, and later, in 1865, devising the percussion cap. By introducing initiating detonation he laid the foundation of modern blasting technique.

In 1863, in the midst of these activities, he returned to Sweden where his father had preceded him after government orders had ceased with the close of the Crimean War. There he joined his father and brothers in attempts to introduce nitroglycerin in ordinary blasting and mining operations. In 1864 their laboratory at Heleneborg blew up, and his brother, Emil, was killed in the explosion. Undaunted by even so terrifying a disaster, Alfred pushed on and succeeded in forming a Swedish company to exploit his inventions and especially to manufacture nitroglycerin on a commercial scale. Success favored him, and in 1865 a factory for the purpose was completed outside Stockholm and another erected at Krummel near Hamburg.

Nitroglycerin was now a commercial article, but since accidents frequently occurred in its transportation, Nobel set himself the task of making it safe to handle, solving it in 1866 by causing nitroglycerin to be absorbed in infusorial earth, thus forming a solid substance. He had invented dynamite. Among his later epoch-making inventions may be mentioned gelatine dynamite, in 1875, and "ballistit" or "Nobel powder," between 1888 and 1889.

Even in his declining years Nobel remained active in research, and after having moved his residence to San Remo, in 1890, he brought his laboratory with him. There his days ended on December 10, 1896.

It may seem a contradiction in the life of Alfred Nobel that while he gave his

lifelong efforts towards developing and perfecting the most devastating means of warfare, he at the same time was deeply and actively interested in universal peace, and his ideas in that regard bear resemblance to those underlying the foundation of the League of Nations. But his was an altogether unusual personality. In his creative activity he was predominantly an extravert, yet while his superior intellect was in the first place directed towards practical tasks, his personality bore a distinct trait of romantic idealism, and while pursuing his activities with unwonted energy, he was possessed in an uncommon degree of Nordic melancholia, which frequently made him depreciate his work. He was a lonely man—he never married—and shy in the extreme.

In his will, dated November 27, 1895, Nobel left practically his entire fortune, 31,400,000 kronor, the accumulated fruit of his inventions, for a fund, the income from which was to be devoted to giving prizes to those who had "done the greatest service to mankind" in the fields of physics, chemistry, medicine, literature and efforts towards peace. The terms of his will were subsequently translated into the statutes of the Nobel Foundation, which received royal confirmation in 1900.

JOHAN LILJENCRANTS

HALF-MAST ON THE PASTEUR INSTITUTE

THE Pasteur Institute of Paris is draped in double black. On the twenty-ninth of October the famous assistant director, Albert Calmette, died; and five days later, Emile Roux, the director of the institute, passed away.

Dr. Calmette died at the age of seventy years. He was born in Nice in 1863 and inherited the sunshiny character of his birthplace. As a young man he was the disciple of Pasteur, who authorized him to found the Saigon Pasteur Institut in Indo-China and later on the Institut de Pasteur of Lille. He was well adapted for this, because of his wide experience as an investigator and of his first-rate administrative ability. He spent part of his life as naval surgeon and also as professor of bacteriology and hygiene in the University of Paris and the University of Lille.

In spite of the fact that he contributed considerably to the knowledge of anchylostomiasis, purification of sewage, serologic treatment of snake bites and other topics, his main hobby was always tuberculosis. First he became known in this field by his ophthalmic test. He found that if a dilution of tuberculin was instilled in the eye of an infected person or animal a conjunctivitis followed the instillation. This test is still used in veterinary surgery; however, in humans the different skin tuberculin tests were found more simple and not at all dangerous. The greatest contribution of Calmette is the BCG vaccination. He found that a well-planned slight tuberculous infection, achieved by an almost avirulent bovine strain of tubercle bacilli, confers definite immunity against future tubercle bacillus infections. After twenty-three years of animal experimentation, in 1924 he was ready to use his vaccine on human babies. Since this time the BCG vaccination has become more and more popular in many countries, and up to now about two million children have been inoculated.

The French people became quite emotional about this vaccination; Calmette became a national hero. The Lubeck tragedy taught us that in an improperly run laboratory sad errors might happen. The French Government therefore spent 12 million francs to build a special BCG unit to the old Pasteur Institute. A BCG building was erected, which, like a BCG sanctuary, allows in its culture rooms no entry to any other germ but to the BCG, and no other human beings but the

ALBERT CALMETTE

devoted high priests of the BCG culture. In this way the French Government felt assured that the Lubeck catastrophe could not repeat itself on French soil. The new BCG Institute controls the making and distributing of all the BCG vaccine in France.

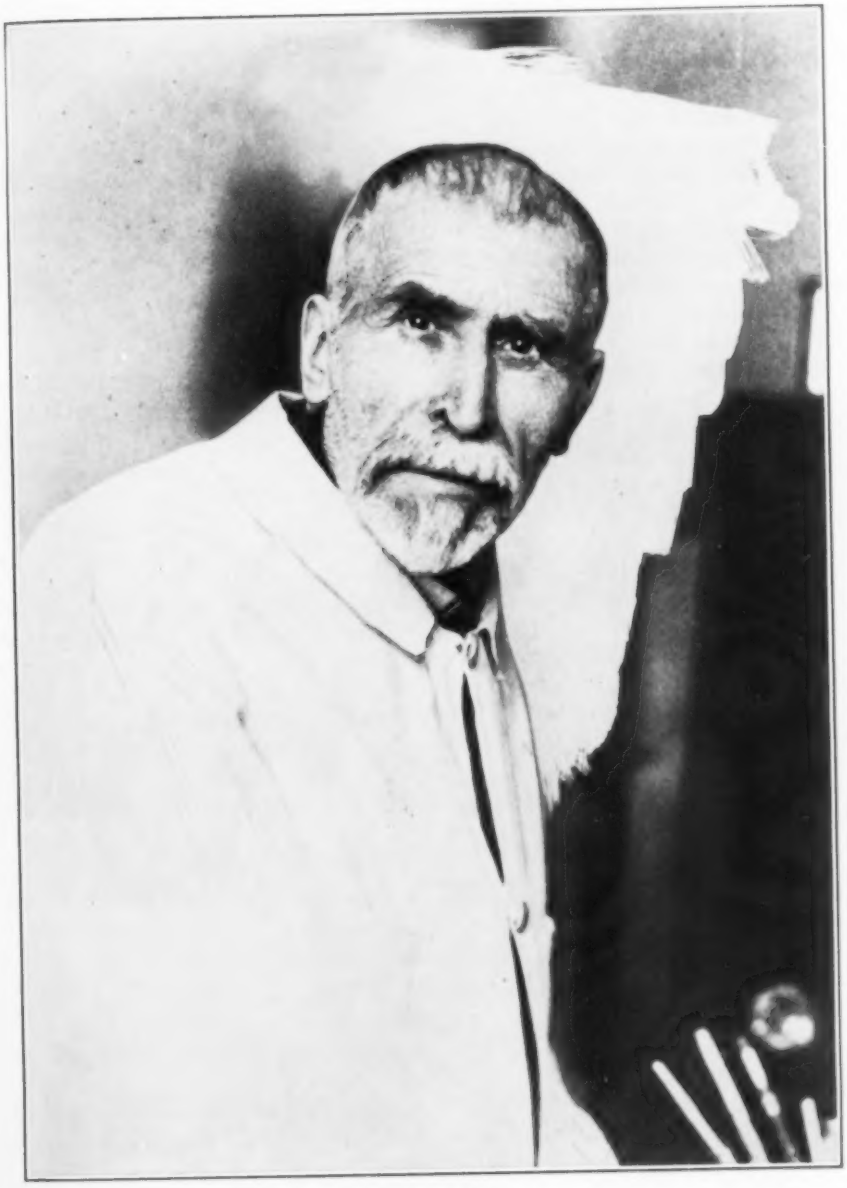
Calmette devoted almost all his time and energy to the BCG problem. He lived in the Pasteur Institute, and every morning at 9 o'clock, sharp, he received his whole staff in his modest working room and listened to a recital about all the happenings of the previous day. He acted toward his staff as a good father acts to his grown-up children, helped them in their scientific and personal problems; made it a point that every one should, so far as lay in his power, be happy and satisfied around him. In the outside world he was just as popular with those who did not oppose his opinions as with those within his laboratory. He was a first-rate orator and could handle any kind and any size audience with theatrical skill. He was honored by being made a member of the French Academy of Science and the Academy of Medicine and was also a visiting member of the Royal Society of Medicine in London. He received just recently the Great Cross of the Legion of Honor from the French Government.

In this country the first BCG vaccine was brought by Nathan Strauss, Jr., and given to Dr. William H. Park to conduct a well-controlled experiment with it. The work has been going on in New York City for the past seven years under the auspices of the health department and with the financial help of the Metropolitan Life Insurance Company. So far the BCG has proved to be not only harmless but also to decrease the tbc mortality to a sixth of the fatality of the controls. Several communities are already giving the vaccine to infants born in tuberculous families.

Calmette's death was most likely caused by coronary thrombosis. He knew for several years that his heart required rest; however, the progress of his BCG vaccination fascinated him so greatly that he kept on working uninterruptedly until death reached him in the midst of his problems in his new BCG laboratory. The mothers of two million BCG vaccinated babies mourn for him in many different countries.

Dr. Emile Roux, director of the Pasteur Institute, died in his eightieth year on November 3, five days after the death of his lifelong friend, Dr. Albert Calmette. Fifty-five years ago, Dr. Roux entered the service of the Pasteur Institute as an assistant of Pasteur. He became a pupil and friend of Pasteur, and was for many years his most talented and valuable assistant and co-worker.

In those early years Pasteur would appear in the laboratory every morning at 9 o'clock and would go over with Roux the next step in the experiments, and Roux and his assistants would then carry them out. His help was invaluable to Pasteur in his researches concerning anthrax, rabies and hydrophobia. As Pasteur grew older, Roux became an independent investigator. Probably the most important work that he carried out as an investigator was upon diphtheria. The discoveries of Klebs and Loeffler, in Germany, had established the fact that the diphtheria bacillus was the causative factor in the development of diphtheria and that it made a specific toxin which did the damage. Pasteur was deeply interested in the nature of this poison, and he detailed Roux, Martin and Chilloux to study its development and whether the toxin was a part of the bacteria or whether it was a separate substance in the culture media. With a Chamberland filter Roux proved that the toxin in the culture fluid was separate from the bacillus, since it passed through the filter. This discovery was of great assistance in the development of antitoxin and the immunization experiments on animals which led quickly to such striking results in Germany and France. In May, 1894, Roux published a paper describing his success in treating success-



EMILE ROUX

fully with antitoxin rabbits suffering with the early lesions of diphtheria. He also established its preventive value when it was given before exposure to infection. Control animals, similarly infected but given no antitoxin, regularly died. By February 1, the animal results were so conclusive that Roux presented the Paris hospitals in which diphtheria was treated supplies of diphtheria antitoxin. The first child was inoculated on February 1, 1894, and made a good recovery. The antitoxin treatment was quickly accepted by the Paris physicians. In September he was able to report good results in hundreds of treated children. We can hardly imagine the enthusiasm aroused by this success, as, until the discovery of diphtheria antitoxin, the world possessed no treatment of value. For his work on diphtheria, he shared the Nobel Prize with Behring.

With his collaborators — Calmette, Chamberland, Duclaux, Nocard and Metchnikoff and others—he carried on investigations along various lines, such as on a cholera serum with Guerin and on syphilis with Metchnikoff. He was very jealous of his institute and of the reputation of the workers in it. He did not take kindly to statements contradicting their conclusions, unless he became convinced of their correctness.

Dr. Roux led an ascetic life. He never married and lived in very simple quarters near the Pasteur Institute. His regular diet was bread and soup. He slept on a hard camp bed. For the past forty years he suffered from an arrested tuberculosis. He took a deep personal interest in all those working in the institute, from his collaborators down to the cleaning women. After he became the director of the institute, he was able to do little individual work, as most of his time was taken up with his administrative duties, the reception of visitors, his consultations with his associates, his committee meetings and his visits to those of the institute who were ill.

On his seventieth birthday, at a meeting in his laboratory, Dr. Roux spoke of the joys of scientific labor not dictated by personal advantage and described the untold satisfaction he found in research and discovery.

Dr. Roux died after a prolonged attack of the grip. He was also depressed by the death of his friend, Calmette, in whose work on the prevention of tuberculosis he was deeply interested and which he supported by his influence. Until his last illness he was able to attend to his duties at the Pasteur Institute. His unusual memory and his ability to help the members of his staff by friendly criticism remained almost unimpaired till the end.

WILLIAM H. PARK

A NEW SEISMOGRAPH STATION

THE new seismograph station of the Massachusetts Institute of Technology, now in operation in northeastern Maine, is the most easterly on the North American continent. Hitherto, no regular seismic observations had been made in this section of the country, the nearest instruments being located at Harvard University in Cambridge and at the Dominion Observatory at Ottawa, Canada.

The station, which has been in preparation for several years, represents one of the most advanced in the design of instruments for recording earthquakes. The isolation of the station, with freedom from artificial disturbances found in and near cities, is considered of great importance, and it was because of this fact that the summer engineering camp of the institute's department of civil engineering near Machias, Maine, was chosen as the location.

The records of the seismographs are sent directly to the headquarters of the U. S. Coast and Geodetic Survey in Washington, where similar records coming from widely separated stations make it possible to determine accurately the

AT TECHNOLOGY CAMP

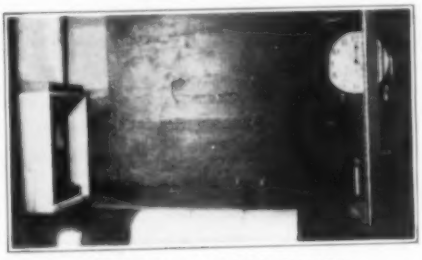
origin of seismic disturbances. The new station is in charge of Professor George L. Hosmer, who during the summer makes his headquarters at Camp Technology.

The building in which the instruments are housed is constructed of concrete, with walls nine inches thick. The interior is lined with two layers of insulating material, separated from the wall and from each other by air spaces. The concrete pier on which the instruments are installed has its foundation on an outcrop of volcanic rock which underlies this section of Maine near the shores of the Bay of Fundy.

The seismographs, which were designed and built by Dr. Frank Wenner, of the U. S. Bureau of Standards, consist of two separate units, one for recording east and west movements of the earth and the other to detect waves of north and south direction. The slightest earth tremor registered by these delicate instruments sets up an electric current, which is transmitted by a special cable to the recording instruments in a building nine hundred feet from the seismograph house.

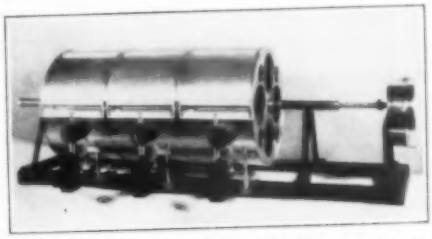
THE SEISMOGRAPH HOUSE

The recording room, located in the basement of the home of E. O. Dennison, resident superintendent of Camp Technology, is light-proof and, in addition to the instruments for receiving earthquake data, is equipped for developing the photographic paper on which the records are registered.



THE RECORDING ROOM

SHOWING THE RECORDER, THE GALVANOMETER AND THE CLOCK.



THE THREE-DRUM CLOCK-DRIVEN RECORDER

The electric currents generated when the seismographs register an earthquake operate an extremely sensitive galvanometer, which, by means of a tiny mirror, writes the message of a distant earthquake with a pencil-point of light. The record is registered on a revolving drum, covered with specially prepared photographic paper. The drum is driven by an accurate clock mechanism, and the exact instant of the beginning and ending of any earth disturbance is automatically noted on the record.

A GROWTH-STIMULATING ACID

PANTOTHENIC acid is the name given by Professor Roger J. Williams, of Oregon State College, to a newly discovered physiologically potent substance, because of its wide-spread occurrence in tissues. In its strictest sense, the Greek word means "from everywhere," and while this acid does not occur either in the stratosphere or beneath the earth's crust, it is so wide-spread that he has found it in all types of living cells—from the tissues of higher animals and plants down to the lowlier forms of life, earthworms, oysters, yeasts, molds, algae and bacteria.

Physiologically active substances, such as hormones and vitamins, are often of limited occurrence and inhere in certain organs and tissues. In no case has it been proved that such a substance is of universal biological occurrence. Pantothenic acid, however, is common to all types of living things. Further research may show that it is one of a group of substances which occurs universally in living matter in very small amounts.

The substance is recognized by its remarkable effect on yeast growth. That its identity has not been established before is due to the fact that it occurs in tissues in very small amounts and also because of its chemical nature—it is an aliphatic hydroxy acid and hence very difficult to crystallize.

By converting the acid into an alkaloidal salt, then after recrystallization into its calcium salt and finally by making use of fractional electrolysis, the acid is obtained in a very highly concentrated form, perhaps approaching purity. The fractional electrolysis in a multiple compartment cell segregates acids and bases of different strengths in the different compartments. The acid, so obtained, can be detected when one millionth of a milligram is present in a cubic centimeter of culture medium.

When this acid is added to a medium containing all the known nutrients for yeast, including inositol and the rarer elements, its effect is striking. Without any of the acid present (except for the small amounts added with the seed yeast or introduced as an impurity with cane sugar) the yeast may multiply tenfold in twenty-four hours. But when pantothenic acid is added, the multiplication may be anywhere up to 100,000-fold or more, depending on the amount added to the medium.

The fact that pantothenic acid has such a striking effect on yeast growth and multiplication, coupled with the observation that it is found in all types of living tissues, suggests the probability that it may have fundamental functions in connection with the general process of growth as known in the animate world.

A further observation which lends interest to this possibility is the fact that organisms which are capable of very rapid growth, such as yeasts, slime molds and mushrooms, are rich sources of the acid. On the other hand, pathologic growths, such as carcinoma, are not associated with large amounts of the acid.

The origin of the acid in nature is as yet obscure. It is not produced by yeast as it grows but is synthesized by *Aspergillus niger*, one of the common molds inhabiting the soil. It is quite possible that the acid, rather than being produced by green plants, is formed in the soil and stored in seeds for the growth stimulation of young seedlings.

Many lines of research are opened by the discovery of this acid. The determination of its exact chemical nature and devising a method for its laboratory synthesis will be important objectives. As to its functions, investigations are under way to determine the rôle which it plays in the growth of other types of yeast, of bacteria and molds and of higher plants and animals.

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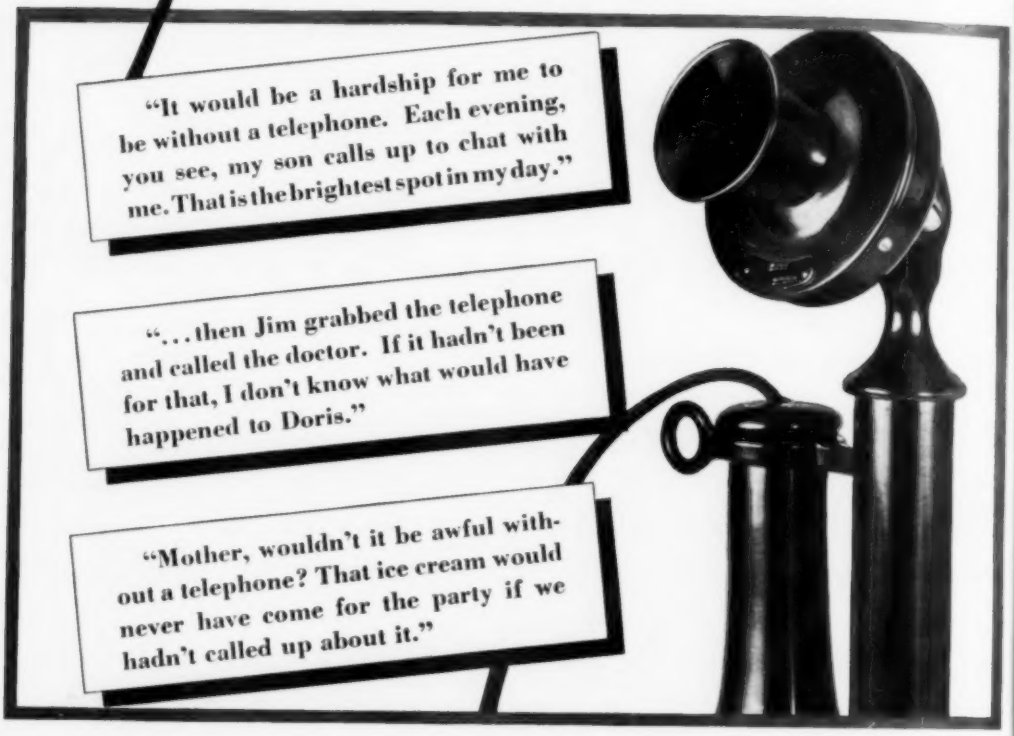
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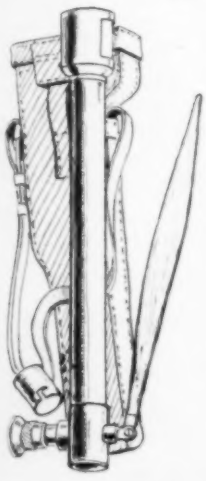

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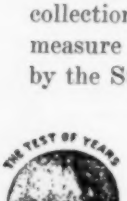

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